

### E.2.3 Summary Description of FFTF Decommissioning Alternatives

DOE needs to decommission FFTF and its support facilities at Hanford; to manage waste associated with decommissioning the facilities, including certain FFTF wastes designated as RH-SCs; and to manage the disposition of the radioactively contaminated bulk sodium inventory at Hanford. Those actions are necessary to protect human health and the environment; facilitate cleanup at Hanford; comply with decisions reached by DOE as a result of previous NEPA reviews (DOE 1995, 2000; 66 FR 7877), as well as Federal and Washington State laws and regulations; and meet enforceable milestones established in the TPA (Ecology, EPA, and DOE 1989, 2002, 2003).

To address anticipated needs for decommissioning FFTF, DOE proposes to complete the following actions:

- Decommission FFTF and associated support facilities within the Property Protected Area (PPA) at the Hanford 400 Area, and manage radioactive and hazardous wastes using existing capabilities.
- Manage certain FFTF wastes designated as RH-SCs using management capabilities that do not currently exist at Hanford or elsewhere.
- Dispose of the inventory of radioactively contaminated bulk sodium resulting from deactivation of FFTF, as well as sodium from the Hallam Reactor and the SRE that is now in storage at the Hanford 200-West Area.

Aspects of the alternatives for accomplishing these proposed actions are as follows. A No Action Alternative is also evaluated, as required by NEPA.

- **Demolition of the facilities within the 400 Area of Hanford.** Demolition of all or part of the facilities in the 400 Area would be required under each of the alternatives evaluated in this *TC & WM EIS*, except for the No Action Alternative. Demolition would result in radioactive and chemically hazardous waste requiring disposal. Disposal of the bulk of this demolition waste would occur on site in disposal facilities approved for Hanford's operational waste (e.g., an onsite IDF). Waste volumes would vary among the alternatives. This *TC & WM EIS* provides the environmental impact information needed for DOE to make informed decisions regarding preferred alternatives based in part on waste volumes generated, worker safety and other environmental risks/impacts, appropriate D&D technologies, and disposal requirements (e.g., appropriate modified RCRA Subtitle C, D, or other barrier designs).
- **Management and disposition of the FFTF RH-SCs.** Currently, no facility exists without modification within the DOE complex for handling or treating the RH-SCs. In February 2009, under the 2009 FONSI (DOE 2009a), DOE selected the Preferred Alternative of decontamination, as necessary, and modifications to one of two existing facilities within the Idaho Nuclear Technology and Engineering Center (INTEC) at INL. The analyses in this *TC & WM EIS* evaluate two options for processing the RH-SCs in addition to the No Action Alternative, as follows:
  - Idaho Option: Removal and shipment of the RH-SCs to INL for treatment in either the New Waste Calcining Facility (NWCF) or the Fluorinel Dissolution Process (FDP) within the Fluorinel Dissolution Process and Fuel Storage Facility (FAST Facility), both of which are at INTEC (see Section E.2.4.4), followed by shipment to and disposal at either NNSS or Hanford.

- Hanford Option: Removal and storage of the RH-SCs on site at Hanford until a new facility, the Remote Treatment Project (RTP), is permitted and built, followed by disposal at Hanford.

A description of both of these facilities can be found in Section E.2.4.4. This EIS provides the environmental impact information on both options for disposition of RH-SCs to allow DOE to make informed, programmatic decisions on treatment capability, construction, location, and operation with respect to the FFTF RH-SCs, as well as other materials requiring remote handling and processing.

- **Management and disposition of radioactively contaminated bulk sodium.** FFTF reactor coolant systems and storage vessels contained about 984,200 liters (260,000 gallons) of radioactively contaminated sodium. Management and disposition of this sodium, along with about 128,700 liters (34,000 gallons) and about 26,500 liters (7,000 gallons) of radioactive sodium from the Hallam Reactor and SRE, respectively, are addressed in this *TC & WM EIS*. Additionally, radioactively contaminated piping and other general demolition wastes would result from decommissioning FFTF. Processing the radioactively contaminated bulk sodium coolant from FFTF, as well as sodium from the Hallam Reactor and SRE, is required under the scope of the FFTF decommissioning actions. This *TC & WM EIS* analyzes the following two options, in addition to the No Action Alternative, for processing this bulk sodium:

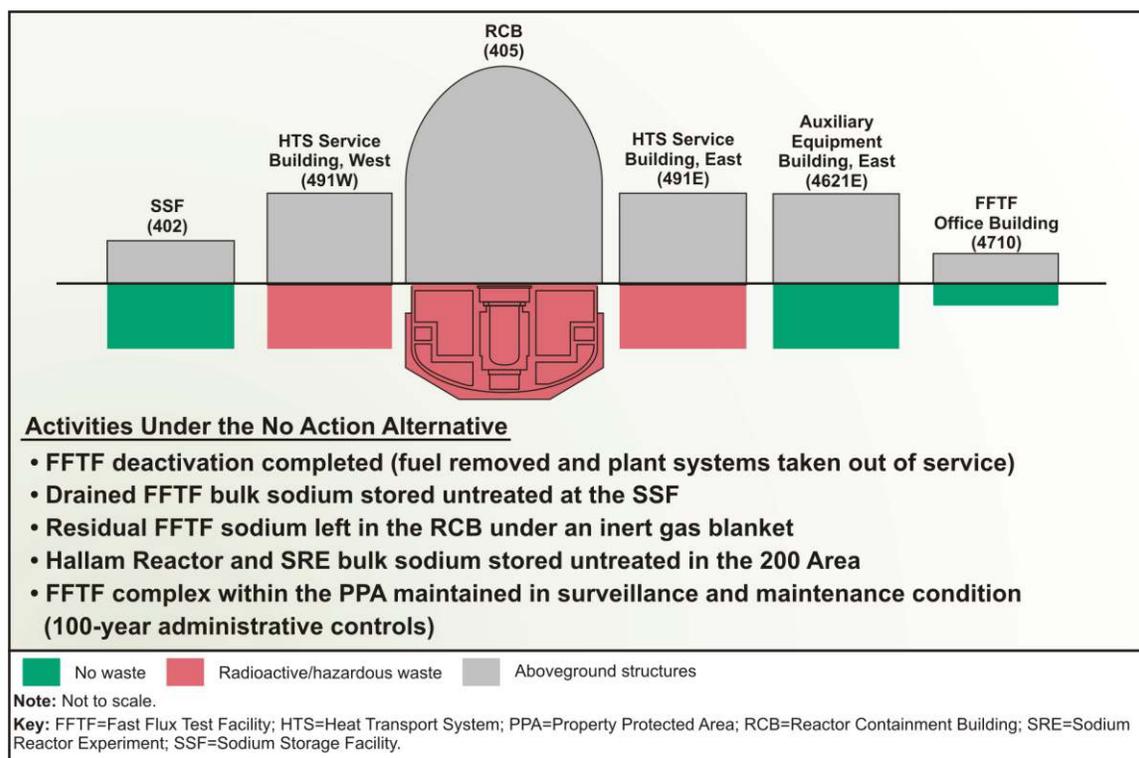
- Hanford Reuse Option: Store the bulk sodium on site at Hanford until a new Sodium Reaction Facility (SRF) is built and the sodium can be processed into a caustic sodium hydroxide solution for product reuse by ORP for the WTP or Hanford tanks corrosion control. This alternative requires permitting and construction of a new facility to convert the reactive radioactive sodium to a caustic sodium hydroxide solution on site at Hanford.
- Idaho Reuse Option: Prepare and ship the sodium to INL for processing into a caustic sodium hydroxide solution and shipment back to Hanford for product reuse by ORP for the WTP or Hanford tanks corrosion control. This alternative requires that the Sodium Processing Facility (SPF) at INL's Materials and Fuels Complex (MFC) be restarted and available for use when required.

In May 2007, the *Hanford Site Sodium Disposition Evaluation Report* (Burke 2007) was issued to document current planning by the TPA agencies for the management and disposition of the radioactively contaminated bulk sodium currently stored at Hanford. Based on planning at the time, the document concluded that conversion of the sodium to caustic sodium hydroxide solution would not utilize the SPF located at INL and anticipated construction of a new conversion facility adjacent to the SSF located in the 400 Area at Hanford. However, as noted in the document, that conclusion does not preclude or predetermine sodium management decisions that may be reached in the DOE NEPA *TC & WM EIS* ROD. Thus, DOE has decided to retain for analysis purposes the option of processing the Hanford radioactively contaminated bulk sodium at the INL SPF.

Descriptions of the SRF and SPF can be found in Sections E.2.4.2 and E.2.4.3, respectively. This EIS provides the environmental impact information for DOE's programmatic decisions on whether to transport the sodium to the SPF at INL's MFC or to permit and construct a new facility, the SRF, at Hanford for processing the bulk sodium.

### E.2.3.1 FFTF Decommissioning Alternative 1: No Action

Council on Environmental Quality regulations require that NEPA analyses include a No Action Alternative. Under this alternative, deactivation of the FFTF complex and support buildings would be completed as specified by previous FFTF NEPA decisions (DOE 2006:Appendix B), so that FFTF can be maintained in a long-term S&M condition for the foreseeable future. The facility would be monitored and periodic S&M performed to ensure that environmental or safety issues are minimized and addressed. Figure E-43 is a graphic representation of this FFTF Decommissioning No Action Alternative.



**Figure E-43. FFTF Decommissioning Alternative 1: No Action**

The impacts of continuing to implement previous decisions would be compared with the potential impacts of the proposed actions under the action alternatives. The following sections provide additional descriptions of activities to be conducted under the No Action Alternative:

**Facility Disposition.** FFTF (the RCB, Building 405), along with the rest of the buildings within the 400 Area PPA, would be maintained in a long-term S&M condition after completion of all deactivation activities. The buildings would be left standing, with a maintained exterior capable of protecting them from the elements. They would be unoccupied, with essential safety-related systems left operational. Such systems could include, but would not be limited to, fire protection, emergency lighting, ventilation, air monitoring, and inert gas systems used to isolate piping and equipment containing sodium residuals.

**Process Components.** The reactor vessel, piping systems, and tanks (contained above and below grade within the RCB and the immediately adjacent buildings) would be left in place under an inert gas (e.g., argon) blanket. Deactivation activities would already be completed, including removal of SNF and lead shielding; draining of the bulk sodium; and removal of small-bore piping, valves, and other components. Some systems (e.g., those not associated with maintaining safety-related functions) would be deactivated/de-energized and isolated per the deactivation plans.

**Sodium Residuals.** Sodium residuals in the RCB vessels and cooling system piping would be left in place, untreated, but under an inert gas (e.g., argon) blanket. During deactivation activities, the FFTF bulk sodium would be drained from the reactor systems and stored as a solid in tanks in the SSF within the 400 Area. The small amount of sodium-potassium alloy would be blended with the content of the bulk sodium storage containers. The sodium from the Hallam Reactor and SRE would remain in its current storage location (Hanford's 200-West Area).

**Demolition and Other Waste.** There would be no demolition under the No Action Alternative; hence, no demolition waste would be generated. Solid and liquid radioactive and/or hazardous waste generated during deactivation would be managed and disposed of on site. Activities associated with the No Action Alternative would not generate substantial additional quantities of solid waste for disposal. The small amounts of radioactive solid waste generated during S&M activities would be disposed of on site in disposal facilities approved for Hanford's operational waste in the existing LLBG trenches. Other regulated waste, such as PCBs, asbestos, and hazardous waste, would be handled in a similar manner under all of the alternatives. The volume of that waste is expected to be small, and it would be disposed of in accordance with existing Hanford facility acceptance criteria or offsite treatment contracts.

**End State.** The facilities and infrastructure within the 400 Area PPA, including the RCB, would be maintained in a long-term S&M condition using appropriate monitoring and controls (to ensure that environmental or safety concerns are minimized) for the foreseeable future.

### **E.2.3.2 FFTF Decommissioning Alternative 2: Entombment**

Under this alternative, the FFTF RCB (and structures within) above grade level (i.e., 168 meters [550 feet] above mean sea level) would be decontaminated as necessary, dismantled, and removed. The RCB structures below grade level, as well as the FFTF reactor vessel and radioactive and contaminated equipment, components, piping, and other materials that have become radioactive or otherwise contaminated, would remain in place. Sodium residuals would be either removed from the RCB and treated in existing 400 Area facilities or treated in place. In addition, the RCB below grade level would be filled with grout or other suitable fill material to immobilize remaining hazardous chemicals and radioactive materials to the maximum extent practicable and to prevent subsidence. The RCB fill material may include other demolition debris containing hazardous or radioactive materials, as allowed by regulations. A modified RCRA Subtitle C barrier would be constructed over the filled area. The barrier, together with the lower RCB and adjacent structures and the immobilized internal structures, would be within the entombed area. A preliminary, conceptual view of the Entombment Alternative is presented in Figure E-44.

The FFTF support buildings would be decontaminated as needed and demolished, as noted in Table E-16. The area previously occupied by the facilities would then be backfilled with soil to eliminate void spaces and then compacted, contoured, and revegetated. An appropriate monitoring program for the PPA would also be established. The following sections provide additional descriptions of activities to be conducted under the Entombment Alternative.

**Facility Disposition.** Table E-16 summarizes the proposed decommissioning activities for each building under both the Entombment and the Removal Alternatives. For the Entombment Alternative, the main RCB and the two immediately adjacent support facilities (Buildings 491E and 491W) would have all above-grade structures (e.g., the RCB dome) dismantled, and the demolition waste would be disposed of in an IDF or consolidated in the below-grade spaces. Below-grade structures would be filled with demolition waste as practicable and stabilized with suitable fill material (e.g., grout) to immobilize hazardous chemical and radioactive materials and prevent subsidence in the future.

All other ancillary buildings, including their internal equipment and components, would be demolished, as noted in Table E–16, and the contaminated demolition debris would be disposed of in an IDF or consolidated within available below-grade spaces within the RCB or Buildings 491E and 491W. All radioactive and/or hazardous material would be removed. Wood and large steel components would also be removed. Foundation rubble (e.g., concrete and rebar) would remain. The area previously occupied by these facilities would be backfilled, compacted, contoured, and revegetated. As indicated in Table E–16, some of these buildings would be either completely or partially within the footprint (including side slope) of the engineered barrier over the RCB.

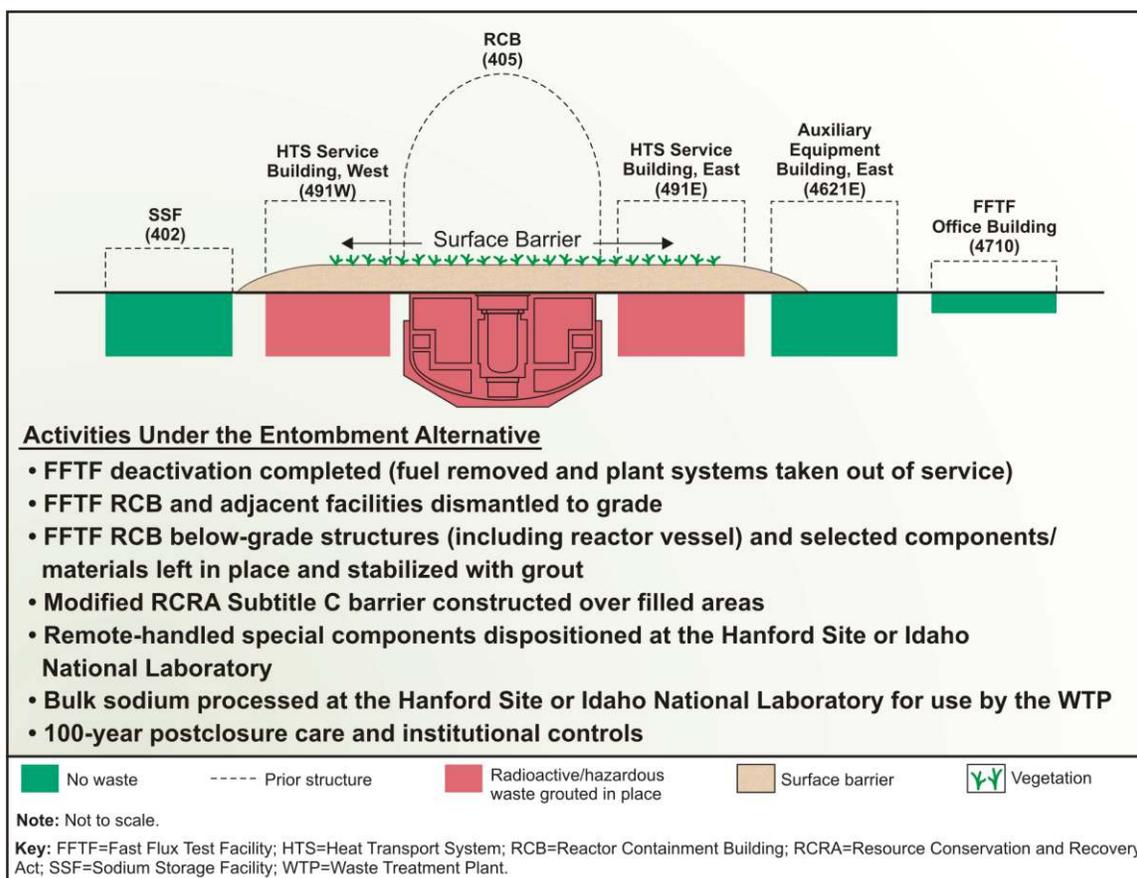


Figure E–44. FFTF Decommissioning Alternative 2: Entombment

Table E–16. Proposed Decommissioning Actions for Hanford Site Fast Flux Test Facility Complex Facilities and Structures

Building Number	Building Name	Action Alternative	
		Alternative 2: Entombment	Alternative 3: Removal
405	FFTF Reactor Containment Building	F	E
491E	HTS Service Building, East	F	C
491W	HTS Service Building, West	F	C
4621E	Auxiliary Equipment Building, East	D	C
4621W	Auxiliary Equipment Building, West	D	C
4703	FFTF Control Building	D	C
4717	Reactor Service Building	D	C

**Table E-16. Proposed Decommissioning Actions for Hanford Site  
Fast Flux Test Facility Complex Facilities and Structures (continued)**

Building Number	Building Name	Action Alternative	
		Alternative 2: Entombment	Alternative 3: Removal
491S	HTS Service Building, South	D	C
408A	Main Heat Dump, East	B	A
408B	Main Heat Dump, South	B	A
408C	Main Heat Dump, West	B	A
409A	Closed Loop Heat Dump, East 1	B	A
409B	Closed Loop Heat Dump, East 2	B	A
403	Fuel Storage Facility	C	C
402	Sodium Storage Facility	A	A
432A	ISA Covered Equipment Storage	A	A
436	Training Facility	A	A
437	Maintenance and Storage Facility	A	A
440	90-day Covered Storage Pad	A	A
451A	Substation	A	A
453A	Transformer Station, East DHX A1 2.4kV	A	A
453B	Transformer Station, South DHX A2 2.4kV	A	A
453C	Transformer Station, West DHX A3 2.4kV	A	A
4701	Former FFTF Guard Station	A	A
4710	FFTF Office Building	A	A
4713A	Riggers and Drivers Operations Facility	A	A
4713B	FFTF Maintenance Shop	A	A
4713C	Contaminated Storage Warehouse	A	A
4713D	Interim Maintenance and Storage Facility	A	A
4716	FFTF Rigging Loft	A	A
4718	400-Area Interim Storage Area Pad	A	A
4721	FFTF Emergency Generator Building	A	A
4734A	FFTF Argon/Nitrogen Pad	A	A
480A	Water Supply Well House (P-14)	A	A
480B	Water Supply Well House (P-15)	A	A
480D	Water Supply Well House (P-16)	A	A
481	Water Pump House	A	A
481A	Water Pump House	A	A
482A	Water Storage Tank (T-58)	A	A
482B	Water Storage Tank (T-87)	A	A
482C	Water Storage Tank (T-330)	A	A
483	Cooling Towers Chemical Addition Building	A	A
484	FFTF In-Containment Chiller Water Equipment Building	A	A
4842B	Switchgear Building for Pump Houses	A	A
SRFa	Sodium Reaction Facility (Proposed)	A	A

**Table E–16. Proposed Decommissioning Actions for Hanford Site Fast Flux Test Facility Complex Facilities and Structures (continued)**

<sup>a</sup> If the U.S. Department of Energy decides to process the bulk sodium at an existing INL facility, the SRF would not be constructed. Decommissioning of the INL facility is not addressed in this *Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington*.

**Note:** Gray shading indicates buildings with reinforced-concrete basements.

A = Demolish and remove building and soils, down to 0.91 meters (3 feet) below grade (if present, subsurface floors and interior walls would be collapsed into the below-grade space; basement exterior walls below 0.91 meters [3 feet] and basement floor and foundations would remain). Backfill to grade with soil, then compact and contour surface and revegetate. Remove all radioactive and/or hazardous material, as well as wood and large steel components. Foundation rubble (e.g., concrete and rebar) would remain.

B = Same as A, except the building footprint would be partially covered by the engineered barrier system.

C = Demolish and remove building down to grade. Remove above- and below-grade components and systems, then collapse floors and walls into the below-grade space at least down to 0.91 meters (3 feet) below grade (basement exterior walls below 0.91 meters [3 feet] and basement floor and foundations would remain). Backfill to grade with soil, then compact and contour surface and revegetate. Remove all radioactive and/or hazardous material, as well as wood and large steel components. Foundation rubble (e.g., concrete and rebar) would remain.

D = Same as C, except the building footprint would be partially covered by the engineered barrier system.

E = Same as C, except small amounts of radioactive activation products in structural concrete and steel would remain.

F = Remove above-grade structures and systems. Contaminated equipment and systems below grade would remain. Consolidate waste and demolition debris below grade, then backfill with grout and cover entirely as part of the engineered barrier system. Radioactive and hazardous waste would remain entombed.

**Key:** DHX=Dump Heat Exchanger; FFTF=Fast Flux Test Facility; HTS=Heat Transport System; INL=Idaho National Laboratory; ISA=Interim Storage Area; kV=kilovolts; SRF=Sodium Reaction Facility.

**Process Components.** The reactor vessel, piping systems, and tanks (contained above and below grade within the RCB and the immediately adjacent buildings) would have all above-grade systems dismantled and placed in below-grade spaces as practicable or transported to an IDF for disposal. Systems that are below grade (including regulated waste) would be grouted in place after treatment of sodium residuals. The small-diameter piping (less than 20.3 centimeters [8 inches] in diameter) would be removed, treated (cleaned of sodium) in the 400 Area, and disposed of on site in an IDF or placed in below-grade spaces within the RCB.

**Sodium Residuals.** All sodium residuals would be removed from the RCB systems or treated in place. The analyses assumed that sodium would be drained from plant systems to the extent practicable, followed by passivation and/or flushing with water to stabilize sodium residuals. Sodium residuals in small-diameter piping would be treated in the 400 Area after removal of the components from the reactor plant.

**Demolition and Other Waste.** Demolition debris from facility decommissioning (chemically hazardous or radioactive solid waste) would be handled in the same way for both action alternatives, except that the disposition of the volumes of debris would change. The debris not placed in the RCB or other voids or used as backfill would be transported to an IDF for disposal. Analyses of solid waste resulting from any of the processing options (for sodium residuals, bulk sodium, etc.) were included in the analyses of those options, specific to the appropriate processing activities.

Radioactive liquid waste resulting from treatment of the sodium residuals would also be handled in the same way for both FFTF Decommissioning Alternatives 2 and 3. The liquid volume would be reduced at FFTF (either through ion exchange and reuse or evaporation), and the remaining liquids would be transported to the 200 Area ETF for processing and disposal. For analysis purposes, it was assumed that a 90 percent reduction in volume could be achieved prior to shipment of the liquid to the ETF for processing. Any other sources of radioactive waste (such as decontamination solutions) are expected to result in very small volumes compared with those produced as a result of treating sodium residuals.

Other regulated waste, such as PCBs, asbestos, and nonradioactive hazardous waste, would be handled in a similar manner under all of the FFTF Decommissioning alternatives. The volume of that waste is

expected to be small, and it would be disposed of in accordance with existing Hanford facility waste acceptance criteria or offsite treatment contracts.

**End State.** For the analyses in this *TC & WM EIS*, an engineered barrier that is compliant with regulations (see Figure E-28), such as a modified RCRA Subtitle C barrier, was assumed to be constructed over the remaining below-grade portions of the RCB and Buildings 491E and 491W, which would contain radioactive and/or hazardous waste. The barrier also would extend over part or all of the immediately adjacent facility footprints. The barrier would be circular with a radius of about 39.2 meters (128.5 feet), not including the side slope used for drainage. The side slope would be about 5.2 meters (17.1 feet), using a 3H:1V slope. Minimal site postclosure care and maintenance would be required. The remainder of the PPA would be backfilled with soil, compacted, contoured, and revegetated.

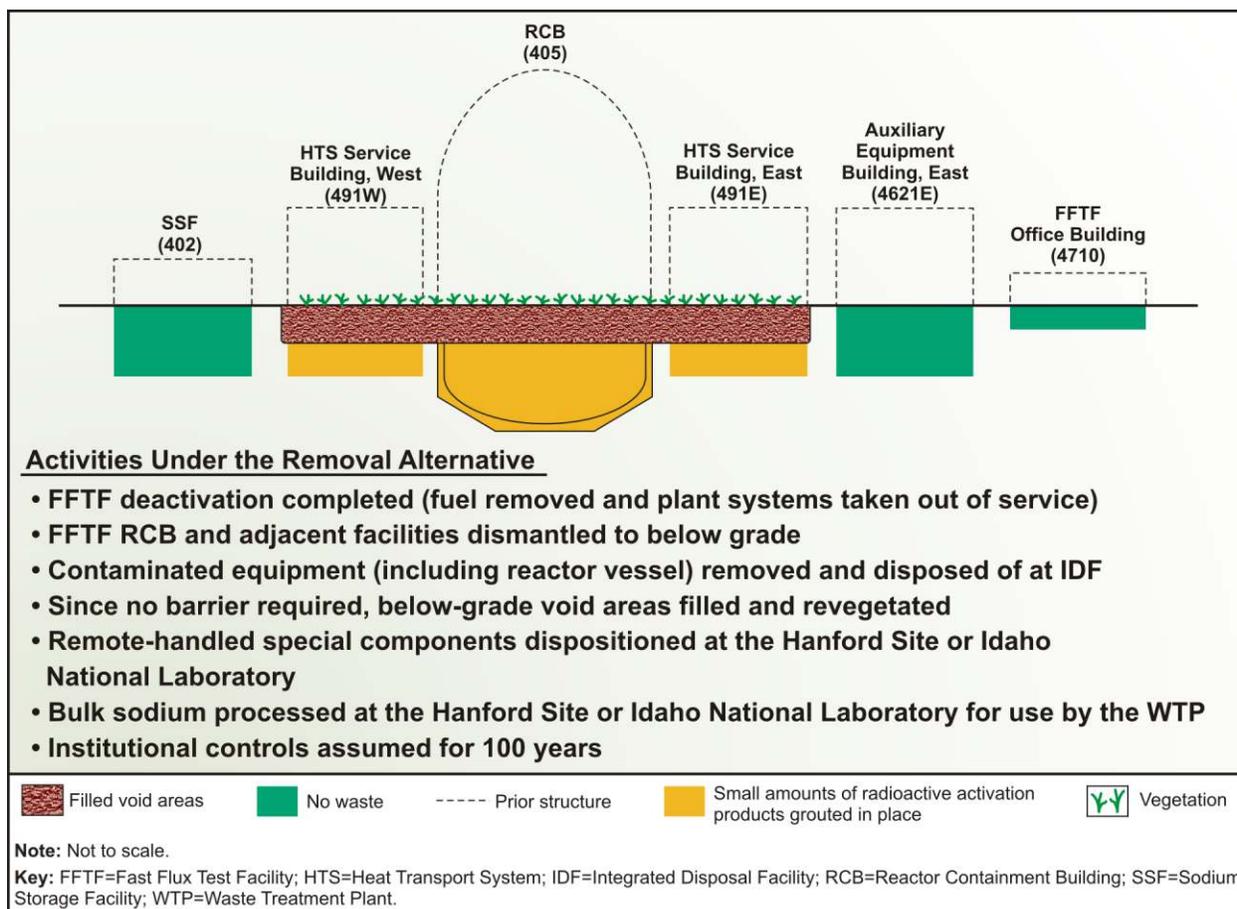
The modified RCRA Subtitle C barrier would be designed to provide long-term containment and hydrologic protection for a performance period of 500 years, assuming no maintenance is performed after a 100-year institutional control period. This performance period is conservatively based on radionuclide concentration and activity limits for Category 3 LLW. The modified RCRA Subtitle C barrier would be composed of eight layers of durable material with a combined minimum thickness of about 1.7 meters (5.7 feet), excluding the grading fill layer, which would range from zero at the edge to around 0.8 meters (2.6 feet) at the center for a 2 percent drainage slope. This design incorporates RCRA “minimum technology guidance” (EPA 1989) with modifications for extended performance. One deviation from the guidance consists of elimination of the clay layer, which may desiccate and crack over time in an arid environment. The geo-membrane component was also eliminated because of its uncertain long-term durability (hundreds to thousands of years). The design incorporates an asphalt layer to inhibit bio-intrusion or inadvertent human intrusion (SAIC 2010d).

### **E.2.3.3      FFTF Decommissioning Alternative 3: Removal**

Under the Removal Alternative, the RCB (and structures within) above grade level would be decontaminated as necessary, dismantled, and removed. All sodium residuals would be removed from the RCB or treated in place to neutralize its chemical reactivity. Below grade, the reactor vessel and its contaminated internals, as well as other radioactively contaminated equipment, components, piping, and materials, including any asbestos, depleted uranium shielding, and lead shielding, would also be removed. Such radioactively contaminated equipment, components, piping, and materials would include the intermediate heat exchangers, primary pumps, primary isolation valves, primary overflow tanks, interim examination and maintenance cell equipment, 8.5- to 12.2-meter-long (28- to 40-foot-long) test assembly hardware, and the interim decay storage vessel. Additional radioactively contaminated equipment from the RCB and the FFTF heat transport system would also be removed. Upon removal, this equipment and material would be disposed of in appropriate Hanford 200 Area disposal units in an IDF. The below-grade RCB and the structures within, as well as the FFTF support buildings outside the RCB area, would be decontaminated as necessary and demolished. The area previously occupied by the facilities would then be backfilled with soil to eliminate void spaces, compacted, contoured, and revegetated. An appropriate monitoring program would be established. Figure E-45 is a graphic representation of the Removal Alternative. The following sections describe the activities to be conducted under the Removal Alternative.

**Facility Disposition.** Table E-16 summarizes the proposed decommissioning activities for each building under both the Entombment and the Removal Alternatives. Under the Removal Alternative, the main RCB and the immediately adjacent support facilities with substructures (basements) would have all their above-grade structures dismantled and the contaminated demolition debris would be disposed of in an IDF. The RCB would be demolished to grade and the support facilities would be demolished to 0.91 meters (3 feet) below grade. Below grade, radioactively contaminated components and equipment

(including the reactor vessel) would be removed. However, the reinforced-concrete cavity in the RCB would remain to be backfilled with either soil or grout to minimize void space, and the surface would be contoured and revegetated. Small amounts of radioactive activation products in structural concrete and steel would remain. As discussed in the following sections, all small-diameter pipes would be removed, and sodium residuals would be either treated in place or removed from the RCB for treatment at an onsite facility to neutralize the chemical reactivity of the metallic sodium.



**Figure E-45. FFTF Decommissioning Alternative 3: Removal**

All other ancillary buildings, including their internal equipment and components, would be demolished and removed (down to a depth of 0.91 meters [3 feet] below grade). The contaminated demolition debris would be removed to an IDF for disposal, and the vacated spaces would be backfilled, compacted, contoured, and revegetated. All radioactive and/or hazardous material would be removed. Wood and large steel components would also be removed. Foundation rubble (e.g., concrete and rebar) would remain.

**Process Components.** The above- and below-grade reactor vessel, piping systems, and tanks within the RCB and the immediately adjacent buildings would be dismantled and transported to an IDF for disposal. Radioactively contaminated equipment, components, piping, tanks, and hazardous materials (including asbestos and lead shielding) would also be removed for disposal in an IDF. The reactor vessel (along with any internal piping and equipment and attached depleted uranium shielding) would be filled with grout, removed, packaged, and transported to an IDF for disposal. Uncontaminated (clean of radioactive or hazardous substances) material would not be removed, and, as previously stated, the reinforced-concrete cavity would remain. All small-diameter piping would be removed and treated in the

400 Area to remove sodium residuals, and the decontaminated equipment piping would be disposed of on site in an IDF.

**Sodium Residuals.** In the same manner as for the Entombment Alternative, all sodium residuals would be removed from the RCB systems or treated in place under the Removal Alternative. It was assumed that sodium would be drained from the plant systems to the extent practicable, followed by passivation and/or flushing with water to stabilize sodium residuals. Sodium residuals in small-diameter piping would be treated in the 400 Area after the components are removed from the reactor plant.

**Demolition and Other Waste.** Demolition debris, radioactive solid waste, radioactive liquid waste, and other regulated hazardous waste would be handled in the same manner for both action alternatives. Under the Removal Alternative, the demolition waste would be disposed of in an IDF.

**End State.** Below-grade portions of structures would be backfilled with soil, compacted to eliminate void spaces, contoured such that natural settling would not result in depressions (to avoid the potential for ponding of water), and revegetated. An appropriate site postclosure care program would be established.

## **E.2.4 FTFF Decommissioning Alternative Process Descriptions**

### **E.2.4.1 Hanford Bulk Sodium Processing**

There are approximately 1.1 million liters (300,000 gallons) of Hanford radioactively contaminated sodium that need to be disposed of. This inventory consists of three separate categories of sodium, as follows:

- **FTFF sodium.** The FTFF reactor, located in the 400 Area of Hanford, ceased operation in April 1992 and was maintained in a standby condition from January 1997 until December 2001, when DOE issued a decision to permanently deactivate the facility. Since that time, activities have focused on preparing the facility for deactivation. Historically, FTFF has reported a sodium inventory of approximately 984,200 liters (260,000 gallons) (Burke 2007). This estimate was revised and the current sodium inventory estimate is approximately 958,000 liters (253,000 gallons). As of June 2007, approximately 916,000 liters (242,000 gallons) of radioactively contaminated bulk sodium have been drained and transferred to the SSF (Chapin 2007). The SSF tanks have a total capacity of approximately 1.1 million liters (300,000 gallons).
- **Hallam sodium.** The Hallam Reactor, located in Hallam, Nebraska, shut down in 1964, and its approximately 128,700 liters (34,000 gallons) of sodium were received at Hanford in 1967. This sodium is stored in solid form under an inert cover gas in five storage tanks at the 2727-W Hallam Sodium Storage Building in the 200-West Area at Hanford (Burke 2007).
- **SRE sodium.** The SRE sodium, approximately 26,500 liters (7,000 gallons), was received at Hanford in 1975 from the SRE, located at the Santa Susanna Field Laboratory, California. This sodium is stored in solid form in 158 208-liter (55-gallon) drums sealed within 322-liter (85-gallon) overpacks. The SRE sodium is stored in eight South Alkali Metal Storage Modules in the 200-West Area CWC at Hanford (Burke 2007).

Based on the historical estimate (i.e., 1.1 million liters [300,000 gallons]), the approximate quantities of Hanford sodium remaining to be processed and the resulting quantity of 50 weight-percent caustic sodium hydroxide solution that would be produced are shown in Table E-17. The 2.5 million liters (667,000 gallons) of sodium represent less than 40 percent of the caustic sodium hydroxide solution additions required by the WTP pretreatment processes (waste processing and caustic leaching) (ANL-W and Fluor Hanford 2002).

**Table E–17. Hanford Site Radioactive Sodium Inventory**

Sodium Category	Sodium		50 Weight-Percent Caustic Sodium Hydroxide Solution	
	Liters	Metric Tons	Liters	Metric Tons
FFTF	984,200	950	2,176,600	3,360
Hallam	128,700	130	287,700	450
SRE	26,500	30	60,600	90
<b>Total</b>	<b>1,139,400</b>	<b>1,110</b>	<b>2,524,900</b>	<b>3,900</b>

**Note:** To convert liters to gallons, multiply by 0.26417.

**Key:** FFTF=Fast Flux Test Facility; SRE=Sodium Reactor Experiment.

**Source:** ANL-W and Fluor Hanford 2002.

Two options for disposal of Hanford's sodium inventory are being considered: the Hanford Reuse Option and the Idaho Reuse Option. To understand whether the radiation levels in Hanford's sodium inventory could affect the feasibility of the caustic conversion process for either option, sodium activity levels were obtained and decayed to October 2008, the assumed date used for the start of processing in the *Hanford Site Sodium Disposition Trade-Off Study* (ANL-W and Fluor Hanford 2002). Table E–18 summarizes the sodium activity levels for the major contaminants, decayed appropriately, and compares them with Experimental Breeder Reactor II (EBR-II) and Enrico Fermi Nuclear Generating Station (Fermi) sodium activity levels (at time of processing). Though the activity levels are low, this material does not qualify as nonradioactive material according to the U.S. Department of Transportation.

**Table E–18. Significant Radioisotopes in Sodium**

	Isotope (nCi/gram)			Date of Activity
	Sodium-22	Cesium-137	Hydrogen-3 (Tritium)	
FFTF primary sodium	5.6	$4.8 \times 10^{-2}$	$5.2 \times 10^1$	October 2008
Hallam sodium	$4.6 \times 10^{-4}$	$4.9 \times 10^{-4}$	$1.2 \times 10^1$	October 2008
SRE sodium	$1.8 \times 10^{-4}$	$8.5 \times 10^{-1}$	N/A	October 2008
Fermi sodium	$2.2 \times 10^{-2}$	$5.6 \times 10^{-1}$	1.2	December 1998
EBR-II primary sodium	$2.05 \times 10^1$	$1.09 \times 10^1$	$2.52 \times 10^2$	September 2000
DOT limit <sup>a</sup>	2	2	2	–

<sup>a</sup> Maximum activity for nonradioactive material shipments (49 CFR 173.403).

**Key:** DOT=U.S. Department of Transportation; EBR-II=Experimental Breeder Reactor II; FFTF=Fast Flux Test Facility; N/A=not applicable; nCi=nanocuries; SRE=Sodium Reactor Experiment.

**Source:** ANL-W and Fluor Hanford 2002.

Elemental sodium is a silver, soft, and ductile alkali metal at room temperature and has a density slightly less than that of water. Sodium reacts vigorously with water and steam and is extremely reactive, oxidizing rapidly when exposed to air. It melts at about 190 °C (208 °F) to form a silvery liquid. The normal boiling point of sodium is 1,600 °C (1,618 °F). The basic chemical reaction is an exothermic reaction with water that, for excess water, produces a caustic sodium hydroxide solution and the evolution of hydrogen gas:



Liquid sodium would be transferred from a storage tank into the facility where the reaction would take place and would be controlled by adjusting the injection rate of the liquid reactants. The process would occur in the reactor vessel, which is a nickel pressure vessel (4.6 meters [15 feet] tall by 0.8 meters [30 inches] in diameter). The entire system would use nitrogen as an inert cover and pressurizing gas.

For a 50 weight-percent caustic sodium hydroxide solution, the reaction would occur at approximately 138 °C (280 °F). Offgases emitted during the process would contain hydrogen, nitrogen, and water vapor. They would be exhausted from the vessel, dried, scrubbed, HEPA-filtered, and monitored before venting as a nonflammable nitrogen/hydrogen mixture. The final caustic sodium hydroxide solution would be pumped from the reaction vessel to a fill station where transportation tanks or drums would be used to contain it for storage before shipment off site (ANL-W and Fluor Hanford 2002).

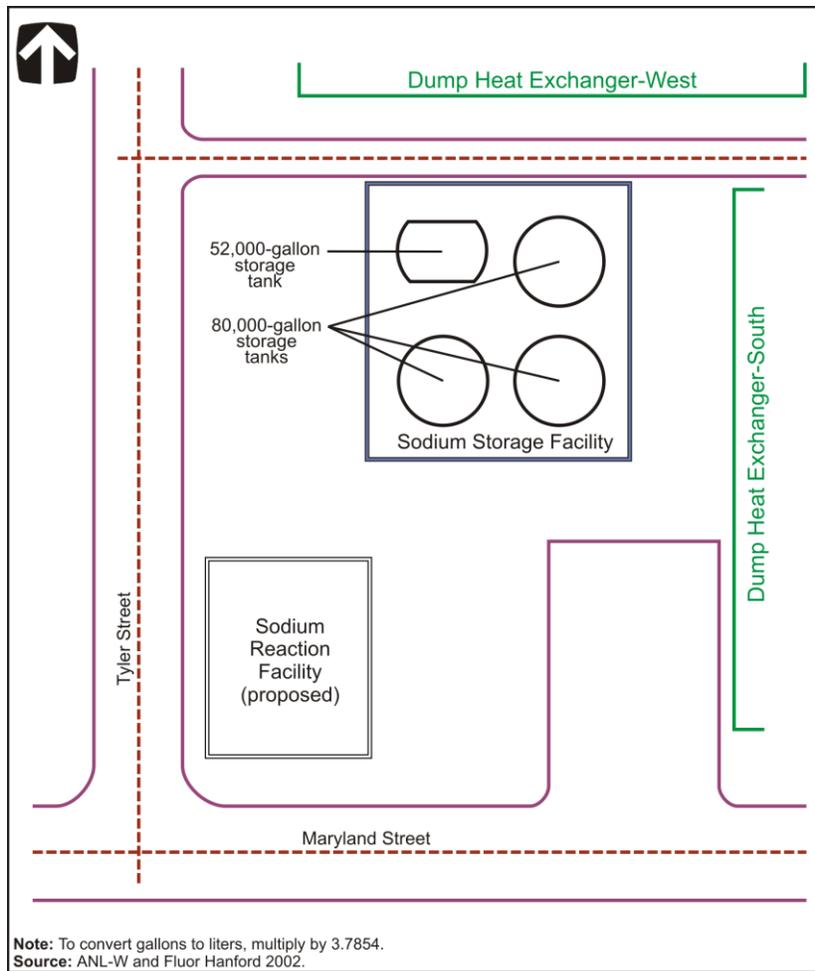
#### **E.2.4.2 Sodium Reaction Facility—Hanford Reuse Option**

This section provides background information on processing of the Hanford bulk sodium at Hanford. The inventory of the Hanford bulk sodium to be processed is described in detail in Section E.2.4.1. The sodium reaction process utilized by the SPF at INL, the model for processing at the FFTF SRF, is described in detail in Section E.2.4.3.

##### **E.2.4.2.1 Description of the Sodium Reaction Facility**

The SRF at Hanford would be used to house the process for converting sodium into a caustic sodium hydroxide solution. The SRF would be directly adjacent to the existing SSF, as shown in Figure E-46. Locating the system adjacent to the SSF would reduce construction and operation costs through the sharing of utilities and operational integration. The SSF, an existing building west of the FFTF south dump heat exchanger, consists of three 300,000-liter (80,000-gallon) tanks and one 200,000-liter (52,000-gallon) tank. The SSF structure is 28 meters long by 27 meters wide by 9.1 meters high (91 feet long by 90 feet wide by 30 feet high). The SSF would be used to store the bulk sodium until its transfer to the SRF for treatment. An exterior photo of the SSF is shown in Figure E-47.

For analysis purposes, this *TC & WM EIS* assumes that the process to be used at the SRF to produce the caustic sodium hydroxide solution would be identical to the process used during the processing of the EBR-II bulk sodium at the SPF at INL. The following subsections describe the individual SRF systems/components.



**Figure E-46. Location of the Sodium Reaction Facility and the Sodium Storage Facility**



Source: ANL-W and Fluor Hanford 2002.

**Figure E-47. Sodium Storage Facility at Hanford**

#### **E.2.4.2.2 Sodium Barrel Melt-and-Drain System**

SRE sodium would arrive at the SRF in its currently packaged 208-liter (55-gallon) drums, each contained in its own overpack, and would be transferred into the SRF day tanks by the barrel melt-and-drain system.

System components would include the following:

- Barrel melt-and-drain stations
- Clamp-on band heaters and thermocouples
- Associated piping (nitrogen supply lines, sodium transfer lines)
- Control panels for each drain station
- HEPA-filtered room exhaust system
- Radiation and contamination detectors

#### **E.2.4.2.3 Sodium Reaction Facility Transfer Line**

The SRF transfer line would be an approximate 3.8-centimeter (1.5-inch) heated, stainless steel, insulated pipeline used to transfer sodium from the SSF to the SRF. An isolation valve would be installed at each end of the SRF transfer line. The transfer line would be designed with a downward slope to maximize draining of the pipe when pumping ceases. As with the SPF transfer line, secondary containment of sodium in double-walled piping would not be required for sodium transfer lines. The transfer line would be trace-heated with resistive heaters and insulated and sealed with a closure system and vapor barrier that would be finished with a weatherproof jacketing material.

#### **E.2.4.2.4 Sodium Transfer System**

This system would transfer sodium from the SSF to the SRF's sodium day tanks. During processing of the sodium, the day tanks would receive sodium from one of two sources:

- SRE sodium from the barrel melt-and-drain system
- FFTF and Hallam sodium from the SSF via the transfer line

There would be two identical carbon-steel sodium day tanks. The SSF nitrogen blanket would be pressurized to push sodium from the SSF to fill one of the day tanks at approximately 110 liters (30 gallons) per minute, while the other day tank would be used for processing.

#### **E.2.4.2.5 Sodium Reaction System**

The reaction system would be used to perform the chemical conversion of liquid metallic sodium to a caustic sodium hydroxide solution. This reaction would take place in the reaction vessel when sodium is transferred from the day tanks to the reaction vessel. This transfer would be accomplished by pressurizing the in-service day tank with nitrogen gas.

The reaction vessel would be a 0.8-meter-diameter by 4.6-meter-high (30-inch-diameter by 15-foot-high) vertical cylinder constructed from caustic corrosion-resistant nickel alloy 200. After passing through an injection nozzle, the sodium would react with water to produce a caustic sodium hydroxide solution and hydrogen gas.

By controlling the atmospheric boiling point of the solution with the periodic addition of water, the concentration of the sodium hydroxide product would be fixed. Sodium would be injected into the reaction vessel through specially designed nozzles capable of adding steam or nitrogen gas (or both) simultaneously at the point of injection. Nitrogen would be introduced into an annulus area at the nozzle

tip to aid in atomizing the sodium upon injection into the reaction vessel. The more completely the sodium was atomized, the greater would be the surface area of sodium exposed and the quieter, less forceful the resulting reaction between the water and sodium as experienced by the SPF. This would also ensure completion of the sodium reaction beneath the surface of the hydroxide solution where the energy release can be readily absorbed, and thus would eliminate the possibility of a carryover of sodium into the offgas. In addition, the capability for initiating a flow of nitrogen or steam to the nozzles after sodium flow was terminated would minimize plugging; if plugging occurred, steam could be used to clear the plug. Each nozzle would have its own electromagnetic flow meter. The nitrogen would be vented from the reaction vessel via the caustic offgas system along with the reaction-produced hydrogen and some water vapor.

The resulting concentration of caustic sodium hydroxide solution in the reaction vessel would be circulated continuously using a caustic recirculation pump. This recirculation pump would take suction from the bottom of the reaction vessel and discharge it near the top of the reaction vessel. Circulation of the caustic sodium hydroxide solution combined with the vigorous nature of the sodium/water reaction would ensure uniform mixing of the solution.

#### **E.2.4.2.6 Caustic Transfer System**

The caustic transfer system would consist of the following components:

- Caustic recirculation pump
- Caustic recirculation line
- 3,800-liter (1,000-gallon) caustic cooling tank
- Caustic product transfer line (with concentric heat exchanger)
- Caustic metering pump
- Caustic transfer pump
- 15,000-liter (4,000-gallon) caustic storage tank

The caustic recirculation pump would take suction from the bottom of the reaction vessel and discharge to piping that would either (1) return the solution to the vessel, (2) divert some of the solution to the product transfer line, or (3) pump down the contents of the vessel to the caustic cooling tank.

The 3,800-liter (1,000-gallon) caustic cooling tank would measure approximately 1.2 meters in diameter by 3.4 meters long (4 feet in diameter by 11 feet long). It would contain a heat exchanger that would reduce the caustic temperature below the levels necessary for caustic corrosion when the product was being pumped from the reaction vessel to the caustic storage tank. The caustic cooling tank also would be used to store some caustic sodium hydroxide solution when the reaction vessel is drained for maintenance. One of the first evolutions to be performed during process startup would involve using the caustic metering pump to transfer this initial charge of caustic sodium hydroxide solution from the caustic cooling tank directly to the reaction vessel. Sodium would be injected into this volume of caustic sodium hydroxide solution to resume processing operations. All piping would be made of nickel because of its corrosion resistance to high-temperature sodium hydroxide.

The caustic transfer system would be equipped with two automatic flow-control valves, as follows:

- One automatic flow-control valve would divert approximately 3.8 to 7.6 liters (1 to 2 gallons) per minute of the caustic sodium hydroxide solution from the caustic recirculation line to the product fill line. This diversion would be set to maintain a specified level in the reaction vessel.
- The other flow-control valve would direct caustic to the caustic sodium hydroxide solution cooling tank during process shutdown.

#### **E.2.4.2.7 Product System**

When the level of caustic sodium hydroxide solution in the reaction vessel reached the control set point, an automatic valve would open, diverting this product solution from the discharge of the caustic recirculation pump to the product container via a product fill line. The product fill container would be determined later by Hanford personnel. The product fill line would be a concentric pipe, counter-flow heat exchanger, which would have an inner pipe (nickel) utilized for high-temperature sodium hydroxide and an outer pipe (stainless steel) containing a coolant (chemically treated water). The fill line would be routed from the process area to the product area.

After a product container was placed in the product area and the fill line nozzle was connected, an operator would actuate a switch on the offload station control panel to begin the product container fill process. If the level of caustic sodium hydroxide solution in the reaction vessel was above the level control set point, it would enable the opening of an automatic valve that would divert caustic sodium hydroxide solution to the product area. The caustic sodium hydroxide solution passing through the product fill line concentric heat exchanger would be cooled prior to entering the product container. When sensors indicated that the product container was full, the operator would actuate another switch on the offload station control panel to temporarily reroute the product to the caustic storage tank. This lineup would allow processing to continue until another product container was connected to the fill-line nozzle. At this point, an operator would sample the full product container for product quality, and concentration would be adjusted as necessary. It would then be sealed and surveyed by the health physics technician to verify outer cleanliness and contact radiation levels. It would then be moved aside to one of the storage bays, and another product container would be put in place to begin the filling process.

#### **E.2.4.2.8 Service and Suspect Water Systems**

Two separate water systems—the service and suspect water systems—would make up the SRF water system. The service water system would be a clean potable water system that functions (1) to cool the offgas condenser and (2) to serve as a heat sink for the product-fill heat exchanger. Service water would be supplied to the SRF from a sitewide source at approximately 690,000 pascals, gauge (100 pounds per square inch, gauge). The primary purpose of the suspect water system would be to provide the water that is injected into the reaction vessel to control the main processing temperature. It would also provide baffle sprays in the reaction vessel and makeup water to the offgas scrubber. The primary source of the water in this system would be the condensation and drains from the offgas system. This water would be potentially contaminated with radioactive constituents. The drains would be collected in a small collection vessel and pumped to a 1,900-liter (500-gallon) water holding tank. A pump would then take suction on the water holding tank and discharge it to the reaction vessel. Makeup water to the system would be supplied to the water holding tank from a deionized water system.

#### **E.2.4.2.9 Caustic Offgas System**

The system would be designed to perform the following actions:

- Contain and recycle the water vapor and caustic carryover from the reaction vessel.
- Remove the gases produced during the process of converting sodium to sodium hydroxide.
- Remove the nitrogen that collects in the vessel from the various purges in the reaction system.
- Provide for filtration, cleaning, and monitoring of gases and particulates carried over in the offgas stream in accordance with environmental and engineering standards prior to their discharge to the environment.

The system would be composed of the following components, as well as interconnecting piping (components are listed in flow path order):

- Reaction vessel baffles
- Reaction vessel demister
- Offgas condenser
- Mist eliminator (mesh-type)
- Scrubber
- Moisture separator (vane-type)
- Parallel prefilters (with polypropylene material)
- Parallel HEPA filters
- Building discharge piping

The principal constituents in the caustic offgas stream as it exited the reaction vessel would be water vapor, hydrogen, and nitrogen. Hydrogen is a reaction product of sodium and water and would make up approximately 60 to 70 percent of the offgas-stream volume at the anticipated SRF sodium injection rate of 2.3 liters (0.6 gallons) per minute to the reaction vessel. Nitrogen would be used to atomize the sodium in the reaction vessel injection nozzles, to do the initial purge of the reaction vessel and offgas system, and to provide an inert cover gas in all process system tanks and vessels to eliminate oxygen. The caustic offgas system would process this gas stream and ultimately release hydrogen and nitrogen outside the SRF building to the atmosphere and return the condensed water vapor to the reaction process. Condensate would be returned to the water holding tank through a series of drain lines.

#### **E.2.4.2.10 Vent Systems**

Two independent vent systems would be associated with the sodium process area and the 15,000-liter (4,000-gallon) caustic sodium hydroxide solution storage tank. All vent system piping would be carbon steel. The vent systems would collect gaseous effluents from all tanks in the sodium process area, including the following:

- 2,760-liter (730-gallon) sodium day tanks
- 3,800-liter (1,000-gallon) caustic cooling tank
- 15,000-liter (4,000-gallon) caustic storage tank
- 1,900-liter (500-gallon) water holding tank

#### **E.2.4.2.11 Steam System**

Steam would be used to clear the injection nozzles in the reaction vessel in the sodium process area.

#### **E.2.4.2.12 Nitrogen System**

Because of the reactive nature of sodium, nitrogen gas would be utilized in the SRF as the primary source of inert gas supplied for all applications requiring a cover gas or motive force.

#### **E.2.4.2.13 Control Air System**

The compressed-air system would be used to perform the following actions:

- Operate the barrel-tilting mechanism for the melting-draining operation.
- Operate the pneumatically actuated valves in the sodium, caustic sodium hydroxide solution, and vacuum piping.
- Operate the pneumatic tilting device to move drums of hydroxide to the drum palletizing area if drums are used as the product fill containers.

#### **E.2.4.2.14 Process Computer System**

The SRF processes would be monitored and controlled using a computer control system consisting of the following components:

- A main control computer
- A graphics computer
- Two bus computers

Process instrumentation and actuators would be connected to the computer control system through input/output channels on the two bus computers. Operators would interact with computer color graphics screens to control and monitor the processes. For certain portions of the process system, operators would interact with the control system through pushbutton/indicator panels located in specific process areas.

#### **E.2.4.2.15 Sodium Throughput**

The SRF is modeled directly on the SPF for throughput. The SPF processed sodium at a nominal rate of 2.3 liters (0.6 gallons) per minute, resulting in about 136 liters (36 gallons) per hour, or 3,220 liters (850 gallons) per day. At this rate, approximately 7,600 liters (2,000 gallons) of 50 weight-percent caustic sodium hydroxide solution could be produced each day (ANL-W and Fluor Hanford 2002).

#### **E.2.4.3 Sodium Processing Facility—Idaho Reuse Option**

The SPF (see Figures E-48 and E-49) was originally constructed in the mid-1980s to convert sodium from the Fermi reactor plant into 50 weight-percent caustic sodium hydroxide solution for use in the PUREX process at Hanford. This use was abandoned after the SPF was constructed, but before it began operations. Once the EBR-II was ordered shut down, defueled, and prepared for deactivation, the SPF was used as a means of preparing the Fermi and EBR-II sodium for disposal at the Radioactive Waste Management Complex at INL. Production operations with radioactive sodium began on December 20, 1998. Processing of all EBR-II and Fermi sodium was completed on March 5, 2001, and the facility was placed in a standby condition. To date, approximately 662,445 liters (175,000 gallons) of radioactive sodium have been processed in the SPF.



Source: ANL-W and Fluor Hanford 2002.

**Figure E-48. Experimental Breeder Reactor II/  
Sodium Processing Facility Complex**



Source: ANL-W and Fluor Hanford 2002.

**Figure E-49. Sodium Processing Facility at the  
Materials and Fuels Complex**

The purpose of the SPF is to react sodium with water to produce a caustic sodium hydroxide solution. The process has the capability of producing any concentration of this solution simply by changing the processing temperature.

This would allow conversion of the Hanford sodium to a 50 weight-percent caustic sodium hydroxide solution, which is specified for use by ORP at Hanford.

The SPF can receive sodium in the following ways:

- The 208-liter (55-gallon) barrels can be delivered directly to the SPF, where the contents can be melted and drained to a sodium storage tank. The Fermi sodium was received in this manner, which would also be the method of transferring the SRE sodium into the facility.
- Sodium can be transferred via a heated pipeline that runs from the secondary sodium drain tank located in the EBR-II secondary sodium boiler building basement. This method was used to transfer EBR-II primary and secondary sodium, and could also be used to transfer the Hallam and FFTF sodium into the SPF.

Once the sodium is in the SPF and in the sodium storage tank, it can be transferred to one of two day tanks, each with a working volume of 2,570 liters (680 gallons), by pressurizing the sodium storage tank with nitrogen gas. During normal operations, one of the day tanks can be filled from the sodium storage tank while the other is used to supply sodium to the reaction vessel, which also can be accomplished by pressurizing the tank with nitrogen gas.

In the reactor vessel, the sodium would react with the water in the caustic sodium hydroxide solution used to initially charge the vessel. This reaction would release heat, which would increase the temperature of the caustic sodium hydroxide solution in the vessel until it reached the control set point. As this would be a saturated boiling system, the end caustic product concentration would be determined by this temperature set point. A 50 weight-percent liquid product would require an operating temperature of 138 °C (280 °F), as opposed to the 186 °C (367 °F) used to process EBR-II sodium into a 70 weight-percent (solid) caustic waste form. Water would be injected into the reactor vessel intermittently to maintain the control set point within  $\pm 0.5$  °C ( $\pm 0.5$  °F).

As the sodium reacts and new caustic sodium hydroxide solution is produced, the level in the reaction vessel would increase. When it reaches the level control set point, operators would begin filling a 15,000-liter (4,000-gallon) tank or direct the 50 weight-percent caustic sodium hydroxide solution to the caustic storage tank until another tank was readied for filling. The majority of instrumentation and system controls at the SPF are coordinated through a control computer in the SPF control room, which permits system operations with minimal operator input (ANL-W and Fluor Hanford 2002).

#### **E.2.4.3.1 Facility Description**

The SPF complex consists of several buildings. These include the original SPF building (and a large addition to it), as well as the caustic storage tank room, an operations support trailer, the EBR-II sodium boiler building, and the sodium transfer line located in the yard area between the sodium boiler building and the SPF.

The SPF currently consists of a four-room metal building housing the barrel melt-and-drain room, barrel holding room, equipment room, control room, and a carbon steel-lined concrete pad on which the process equipment (process area) is located. This part of the building is 20.4 meters long by 17.4 meters wide (67 feet long by 57 feet wide). A newer, large addition to the original building contains the product area. This addition is approximately 22.6 meters long by 7.6 meters wide (74 feet long by 25 feet wide). Two attached storage bays are, in combined outside dimensions, 9.8 meters long by 7.3 meters wide (32 feet long by 24 feet wide).

The SPF is supported on a thickened-edge, reinforced-concrete pad. Most of the exterior is constructed of galvanized-steel siding and roof panels on a structural-steel frame. However, the barrel melt-and-drain room has 30.5-centimeter-thick (12-inch-thick) reinforced-concrete block walls and a 20.3-centimeter-thick (8-inch-thick) reinforced-concrete slab roof. All sections of the building meet the requirements of the Uniform Building Code and Seismic Zone 2 or 2B.

A small metal-sided building, constructed over a lined concrete secondary-containment basin, is just west of the original SPF building. It houses the caustic storage tank. An operations support trailer provides office space, a lunchroom, a locker room, and showers for the operating crews. The EBR-II sodium boiler building houses the secondary sodium drain tank, a recirculation system, and pumps used to transfer sodium to the SPF.

#### **E.2.4.3.2 Barrel Melt-and-Drain Room**

This room contains the eight melt-and-drain stations that would be used to melt the sodium in the 208-liter (55-gallon) SRE drums.

#### **E.2.4.3.3 Barrel Holding Room**

The 208-liter (55-gallon) sodium drums would be brought into this area through a sliding service door in the east exterior wall. This room is a staging area that supports the barrel melt-and-drain room.

#### **E.2.4.3.4 Equipment Room**

This room houses several electrical panels, the remote Met-L-X fire control station for the barrel melt-and-drain room, the constant electric power unit, and several sitewide radio networks utilized by the facility area supervisor. It also is used by the facility area supervisor as office space for conducting facility business, such as work control and lockout/tagout.

#### **E.2.4.3.5 Control Room**

This area contains the main control computer that is used to control and monitor all process functions. It also contains controls for a remote video camera monitoring the process area, three backup computers used to monitor process parameters, and the rest of the emergency communications equipment used by the facility area supervisor for emergency response.

#### **E.2.4.3.6 Process Area**

This room contains all of the major equipment necessary to convert sodium to caustic sodium hydroxide solution. There is a steel-lined secondary-containment basin below all tanks and most piping containing caustic or sodium in this area, as well as systems to detect hydrogen leaks and fires.

#### **E.2.4.3.7 Product Area**

This area houses equipment that was used for filling waste drums when EBR-II sodium was processed and now would be used for filling 15,000-liter (4,000-gallon) tanks after modifications are made. This area also contains chemical analysis equipment for product quality verification, the ventilation system equipment for the main facility, and two bays that can be used for heated storage of product or waste containers. The building height in the main part of the product area is approximately 9.4 meters long and about 3.6 meters wide (31 feet long and about 12 feet wide) in the storage bays. A floor area just inside a rollup door on the east side of the building has an open workspace approximately 9.1 meters long by 7.3 meters wide (30 feet long by 24 feet wide) that would be used to house an International Organization for Standardization (ISO) tank while it is being filled with caustic sodium hydroxide solution (ANL-W and Fluor Hanford 2002).

### **E.2.4.3.8 Sodium Processing Facility Basic System Descriptions**

#### **E.2.4.3.8.1 Sodium Barrel Melt-and-Drain System**

The SRE sodium would arrive at the SPF in its currently packaged 208-liter (55-gallon) drums, each contained in its own overpack, and would be transferred into the SPF sodium storage tank by the barrel melt-and-drain system.

System components would include the following:

- Eight-barrel melt-and-drain stations
- Clamp-on band heaters and thermocouples
- Associated piping (nitrogen supply lines, sodium transfer lines)
- Control panels for each drain station
- HEPA-filtered room exhaust system
- Radiation and contamination detectors
- Fire suppression system (Ansul Met-L-X) for the barrel container assemblies

#### **E.2.4.3.8.2 Sodium Processing Facility Transfer Line**

The SPF transfer line is a heat-traced, 2.5-centimeter-diameter (1-inch-diameter) stainless steel, insulated pipeline that would be used to transfer sodium a distance of approximately 270 meters (900 feet) from the secondary sodium drain tank in the basement of the EBR-II sodium boiler building to the SPF. An isolation valve is installed at each end of the SPF transfer line (i.e., in the sodium boiler building and the SPF). The transfer line is routed out of the sodium boiler building just above grade level and thence west and north toward the SPF. The transfer line enters the SPF through the west wall of the process area and connects to the top of the sodium storage tank at a flange. The transfer line is designed to maximize draining of the pipe when pumping ceases due to its downward slope from the high point just west of the SPF down to the sodium boiler building basement. The transfer line is trace-heated with resistive heaters and insulated and sealed with a closure system and vapor barrier that is finished with a weatherproof jacketing material.

#### **E.2.4.3.8.3 Sodium Transfer System**

This system would transfer sodium from the SPF sodium storage tank to the sodium day tanks. During processing of the Hanford sodium, the sodium storage tank would receive sodium from one of two sources:

- SRE sodium transferred from the barrel melt-and-drain system
- FFTF and Hallam sodium transferred from the secondary sodium drain tank via the transfer line

The secondary sodium drain tank has an effective volume of 56,800 liters (15,000 gallons), and the sodium in this tank could be either recirculated or pumped to the SPF using two annular, linear induction pumps at about 90.8 liters (24 gallons) per minute. The sodium storage tank is a carbon steel storage tank that has a working volume of 16,300 liters (4,300 gallons). A vacuum system is used to create a vacuum in the tank to provide the motive force for sodium transfers into the tank. A nitrogen blanket is also maintained over the tank contents to keep the contents of the tank inert.

There are two identical carbon steel sodium day tanks, each with a working volume of 2,570 liters (680 gallons). The sodium storage tank nitrogen blanket is pressurized to push sodium from the sodium storage tank to fill one of the day tanks at approximately 110 liters (30 gallons) per minute, while the other day tank is used for processing.

#### **E.2.4.3.8.4 Sodium Reaction System**

The purpose of the reaction system is to perform the chemical conversion of liquid metal sodium to a caustic sodium hydroxide solution. Sodium transfer would be accomplished by pressurizing the in-service day tank with nitrogen gas, which provides the driving force for the injection of sodium into the reaction vessel, where the reaction takes place.

The reaction vessel is a 0.8-meter-diameter (30-inch-diameter) by 4.6-meter-high (15-foot-high) vertical cylinder constructed from caustic, corrosion-resistant, alloy 200 nickel. After passing through an injection nozzle, the sodium would react with water to produce a caustic sodium hydroxide solution and hydrogen gas.

By controlling the boiling point of the solution with the periodic addition of water, the concentration of the sodium hydroxide product would be fixed. Sodium would be injected into the reaction vessel through specially designed nozzles capable of adding steam or nitrogen gas (or both) simultaneously at the point of injection. Nitrogen would be introduced into an annulus area at the nozzle tip to aid in atomizing the sodium upon injection into the reaction vessel. The more completely the sodium is atomized, the greater the surface area of sodium exposed and the quieter, less forceful the resulting reaction between the water and sodium. This also would ensure completion of the sodium reaction beneath the surface of the hydroxide solution where the energy release can be readily absorbed, and thus would eliminate the possibility of the carryover of sodium into the offgas. In addition, the capability to initiate a flow of nitrogen or steam to the nozzles after sodium flow was terminated would minimize plugging; if plugging occurred, the steam could be used to clear the plug. Each nozzle has its own electromagnetic flow meter. Nitrogen would be vented from the reaction vessel via the caustic offgas system along with the reaction-produced hydrogen, water vapor, and some caustic carryover.

The resulting concentration of caustic sodium hydroxide solution in the reaction vessel would be circulated continuously using a caustic recirculation pump. Circulation of the caustic sodium hydroxide solution combined with the vigorous nature of the sodium/water reaction would ensure uniform mixing of the solution.

#### **E.2.4.3.8.5 Caustic Transfer System**

The caustic transfer system consists of the following components:

- Caustic recirculation pump
- Caustic recirculation line
- 3,800-liter (1,000-gallon) caustic cooling tank
- Caustic product transfer line (with concentric heat exchanger)
- Caustic metering pump
- Caustic transfer pump
- 15,000-liter (4,000-gallon) caustic storage tank

The caustic recirculation pump would take suction from the bottom of the reaction vessel and discharge to piping that can either (1) return the solution to the vessel, (2) divert some of the solution to the product transfer line, or (3) pump down the contents of the vessel to the caustic cooling tank.

The 3,800-liter (1,000-gallon) caustic cooling tank is 3.4 meters long by 1.2 meters in diameter (11 feet long by 4 feet in diameter). It contains a heat exchanger, which would reduce the caustic temperature below the levels necessary for caustic corrosion when the product is being pumped from the reaction vessel to the caustic storage tank. The caustic cooling tank also would be used to store some caustic sodium hydroxide solution when the reaction vessel is drained for maintenance. One of the first

evolutions performed during process startup would involve using the caustic metering pump to transfer this initial charge of caustic sodium hydroxide solution from the caustic cooling tank directly to the reaction vessel. Sodium would be injected into this volume of caustic sodium hydroxide solution to resume processing operations.

The caustic metering pump is a sealless, magnetic-drive, centrifugal pump with a rated flow of 7.6 liters (2 gallons) per minute. All piping is made of nickel because it resists corrosion by high-temperature caustic. The caustic transfer system is equipped with two automatic flow control valves that function as follows:

- One valve would divert approximately 3.8 to 7.6 liters (1 to 2 gallons) per minute of the caustic sodium hydroxide solution from the caustic recirculation line to the product fill line. This diversion would be set to maintain a specified level in the reaction vessel.
- The other valve would direct caustic sodium hydroxide solution to the caustic cooling tank during process shutdown.

#### **E.2.4.3.8.6 Product Offload**

When the level of caustic sodium hydroxide solution in the reaction vessel reached the control set point, an automatic valve would open to divert this product solution from the discharge of the caustic recirculation pump to the ISO tank via a product fill line. The product fill line is a concentric pipe, counter-flow heat exchanger that has an inner pipe (nickel) utilized for high-temperature sodium hydroxide and an outer pipe (stainless steel) containing a coolant (chemically treated water). The fill line is routed from the process area to the product area.

After an ISO tank was placed in the product area and the fill line nozzle was connected, an operator would actuate a switch at the offload station control panel to begin the ISO tank fill process. If the level of caustic sodium hydroxide solution in the reaction vessel were above the level control set point, it would enable the opening of an automatic valve that would divert caustic sodium hydroxide solution to the product area. The caustic sodium hydroxide solution passing through the product fill line's concentric heat exchanger would be cooled prior to entering the ISO tank.

When sensors indicated that the ISO tank was full, the operator would actuate another switch at the offload station control panel to temporarily reroute the product to the caustic storage tank. This lineup would allow processing to continue until another ISO tank was connected to the fill-line nozzle. At this point, the full ISO tank could be sampled by an operator to verify product quality. It would then be sealed and surveyed by a health physics technician to verify outer cleanliness and contact radiation levels. It would then be moved aside to one of the storage bays, and another ISO tank would be put in place to begin the filling process.

#### **E.2.4.3.8.7 Service and Suspect Water Systems**

Two separate water systems—the service and suspect water systems—make up the SPF water system. The service water system is a clean potable water system. Its functions are to cool the offgas condenser and to serve as a heat sink for the product fill heat exchanger. The service water is supplied to the SPF from a sitewide source at approximately 690,000 pascals, gauge (100 pounds per square inch, gauge) through galvanized-steel piping. The primary purpose of the suspect water system would be to provide the water injected into the reaction vessel that controls the main processing temperature. It also would provide baffle sprays in the reaction vessel and makeup water to the offgas scrubber. The primary sources of the suspect water in this system would be the condensation and drainage from the offgas system. This water would be potentially contaminated with radioactive constituents. The drainage would be collected in a small collection vessel and pumped to the 1,900-liter (500-gallon) water holding tank. A

pump would then take suction on the water holding tank and discharge it to the reaction vessel. Makeup water to the system would be supplied to the water holding tank from the MFC's deionized water system.

#### **E.2.4.3.8.8 Caustic Offgas System**

The system is designed to perform the following actions:

- Contain and recycle water vapor and caustic carryover from the reaction vessel.
- Discharge the gases produced during the process of converting sodium to sodium hydroxide.
- Discharge the nitrogen that collects in the vessel from the various purges in the reaction system.
- Provide filtration, cleaning, and monitoring of gases and particulates carried over in the offgas stream in accordance with environmental and engineering standards prior to their discharge to the environment.

The caustic offgas system has the following components, as well as interconnecting piping (components are listed in flow path order):

- Reaction vessel baffles
- Reaction vessel demister
- Offgas condenser
- Mist eliminator (mesh-type)
- Scrubber
- Moisture separator (vane-type)
- Parallel prefilters (with polypropylene material)
- Parallel HEPA filters
- Building discharge piping

The principal constituents in the caustic offgas stream as it exited the reaction vessel would be water vapor, hydrogen, and nitrogen. Hydrogen is a reaction product of sodium and water and would make up approximately 60 to 70 percent of the offgas stream volume at the rated sodium injection rate of 2.3 liters (0.6 gallons) per minute to the reaction vessel. Nitrogen would be used to atomize the sodium in the reaction vessel injection nozzles, to do the initial purge of the reaction vessel and offgas system, and to provide an inert cover gas in all process system tanks and vessels to eliminate oxygen. The caustic offgas system would process this gas stream and ultimately release hydrogen and nitrogen outside the SPF building to the atmosphere and return the condensed water vapor to the reaction process. Condensate would be returned to the water holding tank through a series of drain lines.

#### **E.2.4.3.8.9 Vent Systems**

Two independent vent systems are associated with the sodium process area and 15,000-liter (4,000-gallon) caustic storage tank. All vent system piping is carbon steel. The vent systems would collect gaseous effluents from all tanks in the sodium process area, including the following:

- 16,300-liter (4,300-gallon) sodium storage tank
- 2,570-liter (680-gallon) sodium day tanks
- 3,800-liter (1,000-gallon) caustic cooling tank
- 15,000-liter (4,000-gallon) caustic storage tank
- 1,900-liter (500-gallon) water holding tank

#### **E.2.4.3.8.10 Steam System**

Steam would be used to clear the injection nozzles in the reaction vessel in the sodium process area. The 1.2-million-pascal, gauge (175-pound-per-square-inch, gauge), steam from the site steam supply would be reduced in pressure to 200,000 to 350,000 pascals, gauge (30 to 50 pounds per square inch, gauge) (measured in respect to atmospheric pressure).

#### **E.2.4.3.8.11 Nitrogen System**

Because of the reactive nature of sodium, nitrogen gas would be utilized in the SPF as the primary source of inert gas supplied for all applications requiring a cover gas or motive force.

#### **E.2.4.3.8.12 Control Air System**

The compressed-air system is supplied by a 25-horsepower air compressor that would provide cool, filtered air at more than 690,000 pascals, gauge (more than 100 pounds per square inch, gauge), for the following uses:

- Operation of the barrel-tilting mechanism for the melting-draining operation
- Operation of the pneumatically actuated valves in the sodium, caustic sodium hydroxide solution, and vacuum piping
- Operation of the pneumatic tilting device to move drums of caustic sodium hydroxide solution to the drum palletizing area

#### **E.2.4.3.8.13 Process Computer System**

The SPF processes would be monitored and controlled using a computer control system consisting of the following components:

- A main control computer
- A graphics computer
- Two bus computers

Process instrumentation and actuators are connected to the computer control system through input/output channels on the two bus computers. Operators would interact with computer color graphics screens to control and monitor the processes. For certain portions of the process system, operators would interact with the control system through pushbutton/indicator panels located in specific process areas (ANL-W and Fluor Hanford 2002).

#### **E.2.4.3.8.14 Sodium Throughput**

The SPF processed sodium at a nominal rate of 2.3 liters (0.6 gallons) per minute, resulting in about 136 liters (36 gallons) per hour, or 3,220 liters (850 gallons) of sodium processed per day. At this rate, approximately 7,600 liters (2,000 gallons) of 50 weight-percent caustic sodium hydroxide solution could be produced each day; thus, 2 days would be required to fill a 15,000-liter (4,000-gallon) ISO tank.

| The SPF processed approximately 658,660 liters (approximately 174,000 gallons) of EBR-II and Fermi sodium in just over 2 years. The plant utilization factor steadily increased over this period. During the initial startup of the SPF, the plant factor was low while engineering personnel refined the process's performance and operations personnel gained experience in how to run the process most efficiently. This is represented by a plant utilization factor of only 11 percent achieved in the first 3 months of process

operation. As experience was gained and lessons learned were implemented, the plant utilization factor increased until an average of approximately 62 percent was achieved for the last 6 months of operation. A projected plant utilization factor of 65 percent for resumed operation of the SPF, or the operation of a completely new facility, is well within expectations due to further implementation of lessons learned. In addition, production of 50 weight-percent caustic sodium hydroxide solution rather than a 70 weight-percent caustic would be much easier on systems and components, resulting in less downtime for repairs and maintenance (ANL-W and Fluor Hanford 2002).

#### **E.2.4.4 Remote-Handled Special Components Processing**

##### **E.2.4.4.1 Fast Flux Test Facility Remote-Handled Special Components Description**

Removal of FFTF RH-SCs, which would be completed under the deactivation work, was evaluated in the 2006 EA (DOE 2006). The removed RH-SCs would be stored within the FFTF complex until the selected treatment facility had been built and was ready to receive them.

As background, FFTF RH-SCs include the primary cold trap (N-5), the cesium trap (N-3), two sodium condenser vapor traps (U-527 and U-532), and the associated filter vapor traps (VT-61, VT-62, VT-63, and VT-64). Each of these components has a high-radiation-dose level due to the presence of high-energy, gamma-emitting fission products (primarily cesium-137). The primary cold trap and the cesium trap both contain sodium residuals (Fluor Hanford 2005c). Each of these components would require remote operations to disconnect and isolate the traps from process system piping, to cap or blind off inlets and outlets, and to remove them from the facility. Isolation and removal of these components is a major activity that must be completed before other D&D activities can occur.

The current plan is to leave the sodium residuals frozen in the traps until after removal and to transport the traps to an interim storage facility (Fluor Hanford 2005c). Due to the inventory uncertainty, it was assumed for analysis purposes that the two vapor traps (U-527 and U-532) would also include their respective filter vapor traps. Two alternatives were analyzed for treatment of these RH-SCs. The first alternative is treatment at INL. The *Final Environmental Assessment for the Remote-Handled Waste Disposition Project* (DOE 2009b), issued February 2009, analyzed four alternatives for the treatment of INL and FFTF RH-SC waste streams, ranging from use of existing facilities at INTEC (the Preferred Alternative) to use of new facilities at the MFC (EA Alternative 4). DOE issued a FONSI (DOE 2009a) on February 18, 2009, selecting Alternative 1: INTEC Existing Facilities Alternative (the Preferred Alternative). The second alternative is to treat these components at a new facility constructed at Hanford. This new facility would be designed and constructed to be the same as the INL facility.

There is currently no NRC-licensed transportation cask with the capacity to handle these traps for shipment to INL. Therefore, this EIS assumes that a transportation cask or other shielded container would exist at the time of removal to transport the RH-SCs to an interim storage facility either at Hanford or at INL. Vehicle emissions for transport of the RH-SCs on site at Hanford or off site to INL were calculated and included in this EIS (SAIC 2010d).

Disposal of the decontaminated RH-SCs would be handled in a number of ways. Under the Hanford Option, the RH-SCs would be disposed of in an IDF at Hanford. However, under the Idaho Option, the decontaminated RH-SCs would be either packaged and sent to Hanford for disposal in an IDF or packaged and sent to NNSS for disposal. For analysis purposes, it was assumed that, under both options (i.e., Hanford or Idaho Options), disposal of the decontaminated RH-SCs would take place at Hanford in an IDF or at NNSS.

The radionuclide inventory of the FFTF RH-SCs is summarized in Table E-19.

**Table E-19. Fast Flux Test Facility Remote-Handled Special Component Inventory Summary**

Component	Sodium Residuals Volume (gallons)	Contact Dose Rate <sup>a</sup> (rem per hour)	Inventory <sup>a</sup> (curies)	Isotope
Cesium Trap (N-3)	80	60	210	cesium-137
Cold Trap (N-5)	710	10	470	cesium-137
			70	cobalt-60
5-scfm Vapor Trap (U-527) and Filter Vapor Trap (VT-63 and VT-64)	<1	5	90	cesium-137
1-scfm Vapor Trap (U-532) and Filter Vapor Trap (VT-61 and VT-62)	<1	0.6	5	cesium-137

<sup>a</sup> The contact dose rates and inventories are assumed or estimated. The isotope inventory is based on the assumed/estimated contact dose rate (i.e., an inventory of either 94 curies of cesium-137 or 14 curies of cobalt-60 would result in the estimated 2-rem-per-hour contact dose rate for the cold trap). Date of estimate was 2005.

**Note:** To convert gallons to liters, multiply by 3.7854.

**Key:** scfm=standard cubic feet per minute.

**Source:** CEES 2006e; DOE 2009b.

Currently, no facility exists without modification within the DOE complex for handling or treating the RH-SCs. In February 2009, under the 2009 FONSI (DOE 2009a), DOE selected the Preferred Alternative of decontamination, as necessary, and modifications in either the NWCF (CPP-659) or the FDP within the FAST Facility (CPP 666) to process the RH-SCs if DOE decides through *TC & WM EIS* decisionmaking that processing of the FFTF RH-SCs should take place at INL. Therefore, this EIS analyzes the following two options under FFTF Decommissioning Alternatives 2 and 3 for processing the RH-SCs:

- Hanford Option: Removal and storage of the RH-SCs on site at Hanford until a new facility is permitted and built, followed by disposal in an IDF at Hanford
- Idaho Option: Removal and shipment of the RH-SCs to INL for treatment in either the NWCF or the FDP within the FAST Facility, both of which are at INTEC, followed by shipment to and disposal in an IDF at Hanford or NNSS

The *Idaho National Laboratory, Conceptual Design Report for the Remote Treatment Project, Annex to the Hot Fuel Examination Facility* (ANL-W 2004) describes a workable concept, an annex to the Hot Fuel Examination Facility (HFEF) at the MFC, for processing RH waste from INL and for handling and shipping the output waste streams. This concept has been applied to both INL and Hanford for the analyses described in this *TC & WM EIS*. Specifically, for the Idaho Option, it was determined that the *Final Environmental Assessment for the Remote-Handled Waste Disposition Project* (DOE 2009b) provides adequate NEPA coverage for construction activities at INTEC and, therefore, this EIS analyzes only the environmental impacts of operation and deactivation of activities similar to those originally planned for the RTP in either the NWCF or the FDP within the FAST Facility. It was also assumed that the environmental impacts of processing the FFTF RH-SCs at INTEC and deactivating the facility would be equal to or bounded by the impacts of the same activities at the MFC. For the Hanford Option, this EIS analyzed the environmental impacts of all three activities (construction, operations, and deactivation) at the RTP, which would be located in the Hanford 200-West Area near the T Plant complex.

At Hanford, the RTP would have the same design as the INL facilities, except that a new high-bay cask-unloading area would be required at Hanford. The INL operation would use hot cells at either the NWCF or the FAST Facility for cask unloading. Thus, equipment and resource utilization (e.g., structural steel) at the Hanford RTP would be higher than that at INL because of the new construction required at Hanford (SAIC 2010d).

#### **E.2.4.4.2 Remote Treatment Project Process and Facility Descriptions**

At INL, either the hot cells located in the NWCF or the FDP cell located in the FAST Facility would be used to perform the necessary processing actions. Modifications to the NWCF cells would involve several hot cells, including Cell 308 and Cell 306. Modifications to the FDP cell would include upgrading to support the necessary remote-handling equipment. Additional details for the necessary modifications are included in the *Final Environmental Assessment for the Remote-Handled Waste Disposition Project* (DOE 2009b).

A description of the proposed remote treatment process for either of the two selected INTEC facilities is included in the *Final Environmental Assessment for the Remote-Handled Waste Disposition Project* (DOE 2009b) and is not repeated here. The following is a brief description of the RTP and the process that would be constructed in the 200-West Area at Hanford.

##### **E.2.4.4.2.1 Process Flow Description**

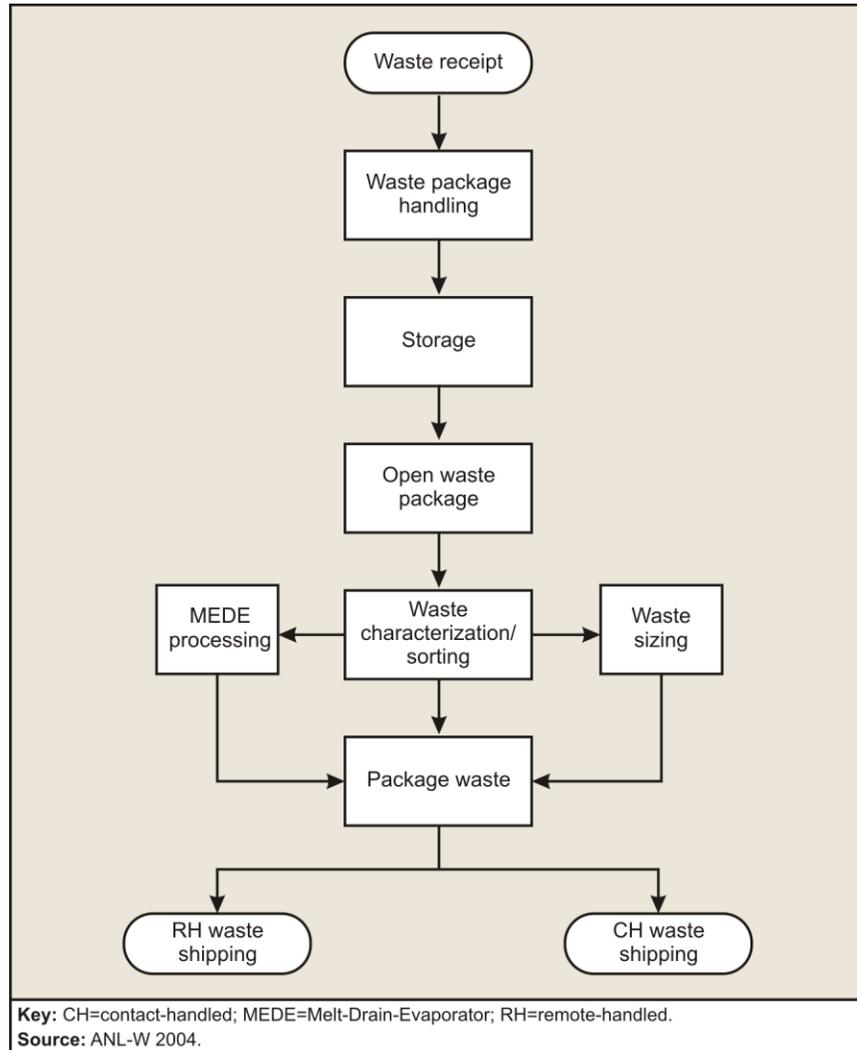
Waste would always enter the processing cell in some type of packaging. The first task would be to open the package and extract the waste. CH debris created during disassembly would be placed into 208-liter (55-gallon) drums, which would then be placed into standard waste boxes for transport and disposal at an appropriate CH disposal facility, depending on the character of the waste. Any RH debris that is generated would be transferred to the RH-waste processing area, sorted at the waste sorter station, and size-reduced so that it could be packaged for removal and disposal. Technicians working with remote manipulators at the hot cell windows would perform visual segregation and characterization. Samples would be extracted and sent to the Analytical Laboratory for quantitative analysis. Figure E-50 shows a simplified waste processing flow diagram.

Other processes would involve use of specialized handling equipment to open specific types of waste containers. There also would be a need to remove sodium from waste components in much of the waste. A melt-and-drain station would be provided at a window for this purpose. The separated sodium would be treated either within the RTP or at another facility. Use of an induction melter station based on an existing design is foreseen for volumetric consolidation of wastes that require deep geologic disposition. Other waste handling and treatment equipment would be installed in the cell as needed for more-specific or future waste processing campaigns.

Waste package handling would occur when waste shipments are received by over-the-road trucks with trailers carrying shielded casks or waste containers. The over-the-road truck and trailer would be backed into the truck lock. The payload would be accessible to a high-bay overhead bridge crane. After proper dismantling of any impact limiters and other protection devices on the payload, it would be lifted off the trailer and placed upright onto a cask cart in the cask tunnel.

A detailed process flow diagram is provided in Appendix C of the *Idaho National Laboratory, Conceptual Design Report for the Remote Treatment Project, Annex to the Hot Fuel Examination Facility* (ANL-W 2004). After the cask was loaded onto the cask cart, a shield ring or bagging ring would be placed on top of the cask. The cart would be moved along its rails into the cask tunnel. Once in the tunnel, the cask cart would be positioned under a cask penetration leading up into the waste-processing cell. The bottom side of the cask penetration in the cask room would have an integral bagging ring. A polyvinyl chloride (PVC) plastic sleeve would be connected between the bagging ring on the cask top and the bagging ring on the cask penetration to provide a contamination barrier against the release of contamination when the top of the cask and the cask penetration are opened. Actuation of the cart's cask-elevating mechanism would lift the top-loaded casks and mate them to the cask penetration in the waste processing cell floor to enable the in-cell crane to extract the waste container from the cask.

After unloading, the cask would be lowered and the bagging sleeve would be heat-sealed between the two sleeve ends. The interior surfaces of the exposed cask top would be cleaned. The emptied cask would then be returned on the cart to the truck lock where the cask's lid would be reinstalled. The overhead crane would lift the cask off the cask cart and place it on the transport trailer. The cask would be prepped for shipment, and the over-the-road truck and trailer with the empty cask would be moved out of the truck lock to the exterior for parking or transport to an offsite location.



**Figure E-50. Simplified Waste Processing Flow Diagram for Remote Treatment Project**

After the waste has been transferred into the waste processing cell, a variety of processing equipment would be used to store, sort, size, process, and repackage the waste. These processes are described in detail in the sections that follow.

The process for transferring processed waste out of the cell would utilize a bagging penetration located in the floor of the waste processing cell. The penetration would be similar to the cask penetration in that it would have a shield plug with a bagging ring on the underside of the penetration to allow the sealed bagging-in or -out of waste and materials.

Below the penetration would be a bag-out room, which would have an elevating mechanism, such as a scissor-lift, to support the shipping container in which the waste is loaded. This room would

accommodate packaging of an LLW 170-liter (45-gallon) inner waste canister, a 110-liter (30-gallon) sodium waste container, or a 208-liter (55-gallon) plastic drum liner into a 208-liter (55-gallon) overpack drum or a designated waste box. The penetration port in the ceiling of this room would have a bagging ring for use with PVC bags sized to fit into the overpack container. The overpack container would rest on a movable electric forklift, and a scissor-lift platform would be underneath the transfer port. The forklift and scissor-lift would have a 900-kilogram (2,000-pound) safe working load. The bottom of the PVC bag would be placed inside the overpack container.

Waste canisters would be lowered down into the overpack container using the cell bridge crane. After the bag has been sealed and cut, a lid would be placed on the overpack container, and it would be moved to the storage area to await transfer out of the facility. A motor-operated lid on the bag-out room side would cover the transfer port in the roof of the drum-bagging room when the port is not being used. The bag-out room would include a jib-mounted plastic heat-sealer that would swing out from the wall to seal the PVC bags. The drum or container would be moved out of the bag-out room and then loaded onto an over-the-road truck and trailer in a fashion similar to that for cask transfers.

#### **E.2.4.4.2.2 In-Cell Equipment and Operations**

Equipment necessary to process initial waste from the Radioactive Scrap and Waste Facility (RSWF) (i.e., liners and their contents, waste cans, and other material) would be similar to other equipment designed and long used at various INL facilities. Maintaining commonality in this fashion would enhance the effectiveness and safety of operations.

The proposed equipment includes the following:

- Liner-disassembly station
- NDA
- Waste can size-reducing device
- Sodium removal (melt-drain-evaporate [MEDE]) system
- Waste-sorting station
- Induction melter
- Melter equipment handling station
- General-purpose work tables

Equipment necessary to process the remaining RH waste is expected to be limited to sorting and size reduction; therefore, a sorting table with size reduction capability would be provided. Additional equipment would be provided based on waste treatment needs.

#### **E.2.4.4.2.3 Liner Disassembly Station**

The liner disassembly station would be capable of handling, unloading, and disassembling both the 41-centimeter-diameter (16-inch-diameter) and 61-centimeter-diameter (24-inch-diameter) RSWF liners and the waste cans. The station would consist of an elevator and a rotational drive assembly, a table with limited vertical and horizontal motions, and a multiaxis, remotely controlled robot arm that operates a cutting tool. The liner disassembly station would be located at a window.

When a liner is brought into the hot cell, it would be transferred to the liner disassembly station, where it would be placed on the elevator stand/rotational drive and clamped into place. The liner would be lowered into the pit using the disassembly station elevator assembly to align the cutting tool with the top of the liner. The liner would then be rotated and the lid of the liner would be cut free.

A pair of PaR Systems 6350 telerobotic manipulators would be near the liner disassembly station to aid in disassembly of the liners. These manipulators may be table- or wall-mounted. The manipulators would provide a 113-kilogram (250-pound) lifting capacity to aid in the automated cutting and handling of the liners. These manipulators have a 1.8-meter (6-foot) reach, are resistant to a cumulative radiation dose of  $1.0 \times 10^9$  rad, have 6 degrees of freedom, and are remotely maintainable. A variety of end-effectors would be used to help cutting tools and grippers lift and move heavy components.

The liner lid would be removed and placed in a CH waste container using the PaR telerobotic manipulators. Once the lid has been removed, and depending on the configuration, either the shield plug would be removed and set aside or a portion of the gravel would be vacuumed out of the 41-centimeter (16-inch) liner. The cutting tool would then be used to cut the top portion of the liner, which would be placed into a CH waste container. This process would continue until the inner waste storage can was exposed and could be removed. Figure E-51 shows a sketch of the liner disassembly station.

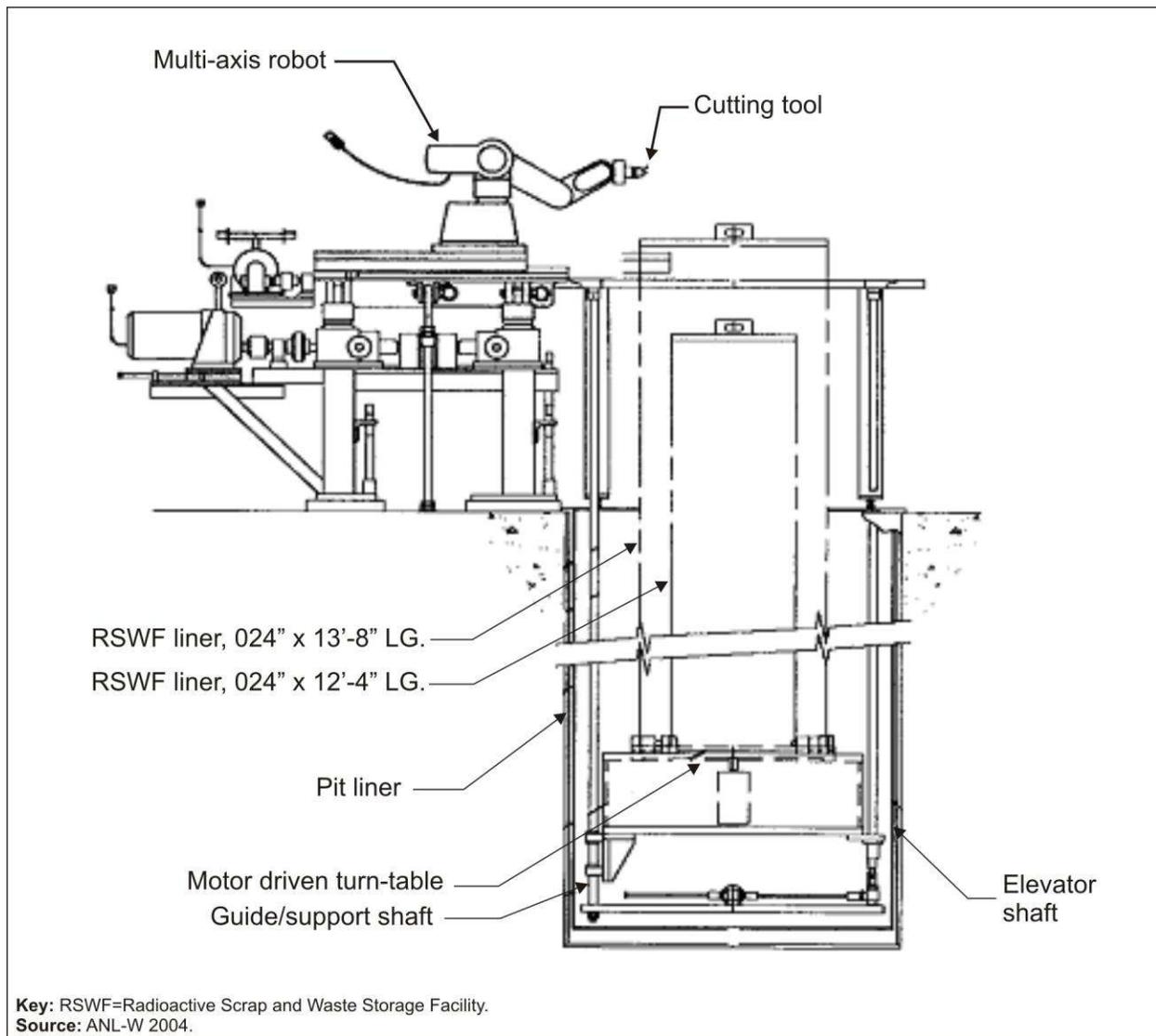


Figure E-51. Liner Disassembly Station

#### **E.2.4.4.2.4 Nondestructive Assay**

Two major NDA process categories would be needed in the RTP: item assays and package assays. Item assays would be used to quantify identifiable, separate items encountered in the repackaging process. Package assays would be used after items have been packaged for shipment. These would be primarily confirmatory measurements. Both categories would use the same basic NDA techniques, but item assays would be more accurate because uncertainties arising from the unknown geometries of packaged items would be either reduced or eliminated.

Both categories would use qualitative gamma-ray spectroscopy (for isotope identification) and quantitative gamma-ray spectroscopy, such as segmented gamma scanning, tomographic gamma scanning, and whole-item-corrected assays (to quantify isotopes whose gamma rays are detectable). Fissile isotopes are not expected to be directly detected in this manner, however.

Both categories would use passive and active neutron measurement methods to quantify fissile materials. Passive methods would count coincident neutrons primarily from plutonium-240 decay, while active methods would induce and count fission neutrons (usually with a coincidence counter) from plutonium-239 and uranium-235. Specific instruments would include the passive-active neutron counter and the shuffler (which is usually active, but can be passive also). A shielded measurement system with a passive coincidence counter may also be used.

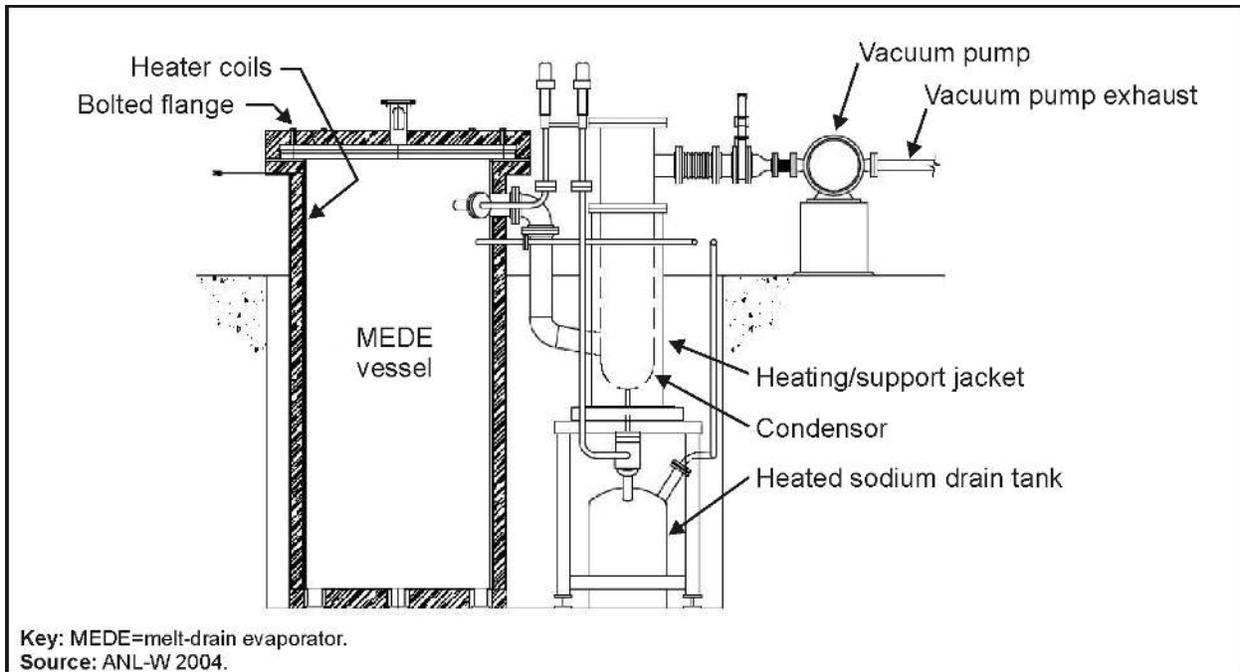
The NDA system would consist of a shielded pipe in the NDA subcell. This pipe would contain an elevator and a turntable to position and rotate the item or waste can within the counters, as well as a shield cover at the top opening at floor level in the RH room. The item or can would be placed on the elevator by the electromechanical manipulator or overhead crane; the elevator would be lowered until the shield cover could be closed, and the object would be lowered and/or rotated in the detectors. After counting, the shield cover would be opened and the object would be retrieved. The instrumentation room could not be manned during operation.

#### **E.2.4.4.2.5 Waste Can Size-Reducing Device**

The waste can size-reducing device would be located in the air cell at a window. The waste can size-reducing device would either compact the waste can tubes or cut the tubes into smaller pieces suitable for denser packing in waste containers such as 208-liter (55-gallon) drums. This machine would be used for CH waste only.

#### **E.2.4.4.2.6 Sodium Removal System**

Much of the RH waste from the RSWF is contaminated with sodium that must be removed or treated prior to shipment. The MEDE system is currently being evaluated for this purpose. The main components of the MEDE system are the vessel, heater, vacuum pump, and sodium storage tank. The MEDE would be located at a window. Figure E-52 is a sketch of the MEDE process equipment.



**Figure E-52. Melt-Drain-Evaporate Process Equipment**

By means of the MEDE process, material to be processed would be placed in an evaporation vessel where it would be heated to melt and drain the sodium. The vessel would be heated further under vacuum to remove the sodium from crevices. Tests completed at INL's MFC showed the MEDE system to be capable of removing sodium from metal samples that had 20-centimeter-deep (8-inch-deep) crevices and from a slot that was 5 centimeters (2 inches) long and only 0.01 centimeters (0.005 inches) wide. Tests completed as part of a Fermi reactor fuel-processing cost estimate at INL's MFC demonstrated greater than 99 percent removal from a fuel cladding annulus over 30 centimeters (12 inches) long with approximately a 0.02-centimeter (0.010-inch) clearance. This was noteworthy in that higher temperatures, approximately 650 °C (1,200 °F), were used to decrease the vacuum required, allowing rather simple and inexpensive commercial dry vacuum pumps to be used instead of oil-sealed or cryogenic pumps (ANL-W 2004).

The majority of the sodium and sodium-potassium present in the waste streams would be contained in bulk in a few of the stored components and could be largely removed using the melt-and-drain step. Sodium metal can be removed by the distillation cycle, but oxide or hydroxide films cannot. Therefore, the system would be provided with a moist carbon dioxide gas stream to react either sodium residual films or reaction product films to produce sodium carbonate, the desired final stable form, and the reaction product could be removed by water-washing if required. CH sodium and sodium-potassium metal removed from the waste streams would be commingled and removed from the cell and deactivated at another facility, while RH sodium and sodium-potassium would be accumulated and later remotely deactivated using equipment.

#### **E.2.4.4.2.7 Waste-Sorting Station**

The waste-sorting station would be used to disassemble waste cans and to remove, resize, and sort the waste into various waste containers. The waste-sorting station would be composed of a support-table assembly, a stand with a vertically driven waste can clamp, a rotating waste can cutting head, a sorting table, a chop saw, and storage locations for various waste containers.

When a waste can (approximately 183 centimeters [72 inches] long and 30 centimeters [12 inches] in diameter) is transferred to the waste-sorting station, it would be placed in the clamp assembly. The cutting head would be moved into position and attached to the waste can, then rotated to cut off the lid. The cut lid would be removed using the electromechanical manipulator and placed into a waste container. The electromechanical manipulator would lift the inner waste can out of the outer waste can and place it in a temporary storage compartment in the table. The outer can would be inverted using the rotating clamp, and the bottom of the can would be removed using the cutter. The can bottom would be placed into a waste container. The electromechanical manipulator would be used to pick up the waste can tube and transfer it to the waste can size-reducing device located in the CH room. The size-reducing device would compact the tube or cut it into pieces suitable for denser packing in a waste container.

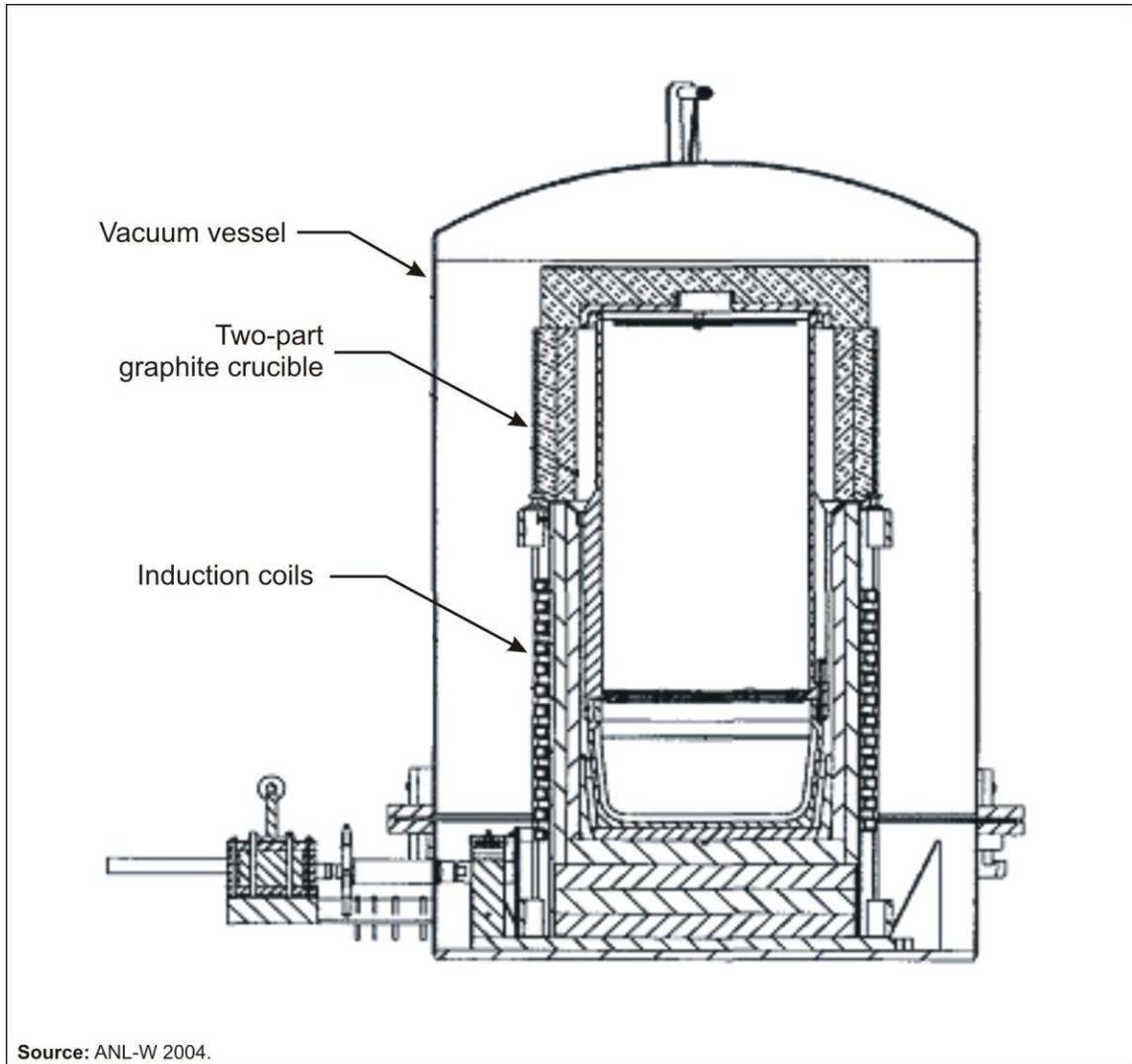
The inner waste can that was temporarily stored in an insert in the table would be lifted using the electromechanical manipulator and set into the clamp. The top lid would be either unbolted or removed using the cutter, and the lid would be placed into a waste container. The inner waste can would be lifted and rotated so that the contents would fall into the sorting tray. The inner waste can would be completely inverted, and the cutter would be used to remove the bottom of the container. The bottom of the inner waste can would be placed into a waste container. The electromechanical manipulator would be used to pick up the inner waste can tube and transfer it to the waste can size-reducing device in the CH room. The size-reducing device would either compact the tube or cut it into pieces suitable for denser packing in a waste container.

The waste in the sorting tray would be segregated into the various types of waste and placed into appropriate waste containers for each waste type. If the waste were subassembly hardware, it might be resized using the chop saw and the pieces placed into the melter crucible. Some of the waste might require additional NDA for accurate characterization. These items could be placed into a new inner waste can and transferred to the NDA cell, after which they would be returned and sorted.

#### **E.2.4.4.2.8 Induction Melter**

The induction melter is used to consolidate irradiated and contaminated metal components, including zircaloy and stainless steel. The melter consists of an insulation assembly, surrounded by a coil assembly, surrounded by the removable vacuum vessel. Graphite crucibles would be placed into and removed from the insulation assembly from the top. An insulated lid would cover the top of the crucibles. This new insulation assembly would be capable of melting waste at 1,700°C (3,092 °F). A typical crucible run would follow these steps: (1) prepare the crucible assembly; (2) load charge materials into the crucible assembly; (3) lower the crucible assembly into the melter; (4) place the lid on the crucible assembly; (5) install the vacuum vessel lid; and (6) evacuate the vessel and backfill with argon, if needed. One melter heatup-cooldown cycle would take approximately 24 hours.

If constructed at Hanford, the induction melter design would follow that of the HFEF Metal Waste Melter at INL, with the addition of an insulation extension and a modified crucible assembly to accommodate longer feed materials. Use of the induction melter would improve volumetric packaging in waste containers while avoiding the particulate contamination created by other mechanical size reduction techniques. Figure E-53 is a sketch of the induction melter.



**Figure E-53. Induction Melter**

#### **E.2.4.4.2.9 Melter-Equipment-Handling Station**

The melter-equipment-handling station would be used to prepare and load crucibles, to dump and sample the ingots, and to package the ingots into waste cans. The station would consist of a modular worktable, including a crucible-dumping/cleaning fixture; sampling equipment; a crucible-loading station; a balance; and ingot, crucible, and tool storage locations. The processed ingots would typically weigh approximately 100 kilograms (220 pounds) based on a high-void-fraction charge.

After completion of the melt-processing, the crucible containing the ingot would be removed from the melter and transferred to the melter-equipment-handling station. The crucible would be placed in a crucible inverter, and the top portion of the crucible would be removed and set down on the table. The bottom portion of the crucible would be clamped into the inverter. An ingot catch-plate would be attached to the inverter, and the crucible and ingot would be inverted. Pins would be removed, and the inverter with the bottom crucible would be lifted off the inverted ingot and catch-plate. The ingot would be weighed and then placed in a waste can using a tong-type lifting device and the electromechanical manipulator.

#### **E.2.4.4.2.10 General-Purpose Worktables**

The worktable would be used to perform equipment repairs using the remote manipulators and for general tasks. The worktable would have a scale for weighing containers and equipment for resizing hardware. The tables would be made of structural steel tubing and would have removable lids covering insert locations used to store tools and small items of equipment.

#### **E.2.4.4.2.11 High-Efficiency Particulate Air Filter Processing**

A HEPA-filter-preparation station would be used to separate the filter media from the filter frames. The radioactively contaminated HEPA filters are approximately 610 millimeters long by 610 millimeters wide by either 15 centimeters or 30 centimeters thick (24 inches long by 24 inches wide by either 6 inches or 12 inches thick). The frames are either steel or wood, and the media consist of aluminum separators and fiberglass paper. The HEPA-filter-processing equipment would consist of a staging area table, a punch press and die assembly, a size-reducing device, and a receiver-can-positioning assembly. The removed filter media would be size-reduced and transferred to additional equipment that would transform the filter media into a powder and mix it with concrete in 208-liter (55-gallon) rigid-plastic drum liners. This additional equipment would consist of a melter, a grinding machine, a hammer mill, and a mixing station to mix the filter media powder with concrete.

The HEPA filter frames would be resized at the waste can size-reducing device if the contamination levels were sufficiently low, and the debris would be placed in the appropriate waste containers. If the contamination levels were high, additional size-reducing equipment would be required for the RH-waste processing area (ANL-W 2004).

#### **E.2.4.4.2.12 Remote Treatment Project Description**

The RTP would provide a shielded, air-atmosphere processing cell designed to ensure complete and reliable containment of radioactive particulates. In addition, the facility would provide support areas, including an administrative area, restrooms and locker rooms, a hot-equipment repair area, a loading dock, a cask-handling area, and adequate space for equipment (e.g., mechanical equipment, electrical equipment, material and waste handling/processing equipment, and backup diesel-fuel-powered generator). The RTP design also would incorporate flexibility to accommodate potential mission changes during the life of the facility.

Plans call for the facility to be a concrete and steel structure approximately 29 meters long by 22 meters wide (94 feet long by 72 feet wide) with an approximate height of 20 meters (66 feet) above grade. The facility would consist of four separate floors: the service floor (basement), the operating floor (grade level), the utility floor, and the high-bay floor. The total floor area (all four floors) would be approximately 2,600 square meters (28,000 square feet). Each of the floors is described in the following paragraphs.

The main features and equipment of the service floor would include a cask tunnel; an NDA cell; heating, ventilating, and air-conditioning supply and exhaust systems; an air compressor; and miscellaneous electrical and water systems. If constructed at Hanford, the cask tunnel would be an approximately 16.8-meter-long (55-foot-long) extension of the HFEF cask tunnel at INL and would provide access to the facility for cask-compatible RH waste.

The NDA cell port would be at the south end of the waste processing cell. This penetration would allow RH waste to be lowered into a shielded cavity where active systems such as a pulsed-neutron source could be set up. In addition, a passive system such as gamma spectroscopy or coincidence-neutron measurements could also be used to interrogate RH-waste streams. This penetration would be sealed to

maintain the cell environment and to prevent the release of contamination to the NDA cell. A data acquisition room would be located outside the NDA cell in the service-floor area.

The operating floor would house the heavily shielded waste processing cell, the loading dock, and the administrative areas. Office space for engineers and technicians would be provided in other existing, nearby facilities. An enclosed personnel passage at ground level would provide sheltered access between the truck lock and the RTP.

The utility floor would house the majority of the electrical panels and cabinets, thereby freeing up space on the operating floor around the processing cell. Restrooms and locker rooms also would be located on this floor. In addition, this floor would have a shielded personnel-access door leading to an upper gallery of the processing cell to allow hands-on repair of in-cell crane drive modules.

The high-bay floor would house the hot repair area, which would consist of a decontamination chamber, a glove wall, a remote-manipulator repair glovebox, an equipment storage area, and a horizontal car transfer station. A hatch on the roof of the waste processing cell would enable equipment and waste to be lowered directly into the cell. The glove wall would be used to repair small components, prepare samples, and conduct bench-top experiments. In addition, there would be space for staging areas, dressing rooms, and a Health Physics counting room.

A diesel generator for standby electric power would be housed apart from the main structure in a lightweight pre-engineered enclosure. The foundation and floor for the diesel generator building would be totally separate from that of the main structure.

A security vulnerability would be eliminated from the storage tank relocation by locating the fuel oil unloading station outside of the security interest area. The pumping station would be located in a new, small building outside of the fenced complex, meaning that fuel trucks would not have to enter the main laboratory area. Fuel oil would be piped from the unloading station to the new location of the fuel oil storage tanks. The access area around the pumping station would be paved and sized to accommodate the maneuvering of a semitrailer truck with another tanker trailer (ANL-W 2004).

### **E.3 WASTE MANAGEMENT**

#### **E.3.1 Current Hanford Site Solid Waste Operations Complex**

Each current Solid Waste Operations Complex (SWOC) facility performs duties to achieve Hanford's waste management goals. These duties are generally complementary, and each facility contributes to the overall process. However, some processes and activities are performed at more than one facility, either because it is necessary or because it maximizes flexibility and project efficiency. The primary processes for each facility include receipt, staging, storage, repackaging, treatment, and shipment of waste, all of which must comply with the waste acceptance criteria. By facility, those activities are as follows:

- **LLBGs:** Retrieve suspect TRU waste, LLW, and MLLW; dispose of LLW and MLLW; and store certain RH wastes.
- **CWC:** Provide interim storage of LLW, MLLW, TRU waste, mixed TRU waste, and certain RH wastes (limited treatment and drum processing is planned for the CWC).
- **T Plant:** Clean out stored waste and contaminated equipment; store waste; decontaminate equipment; and verify, sample, treat, and repack LLW, MLLW, TRU waste, and RH wastes.
- **WRAP:** Confirm, repackage, certify, sample, assay, perform NDE of, and treat LLW, MLLW, and TRU waste for disposal.